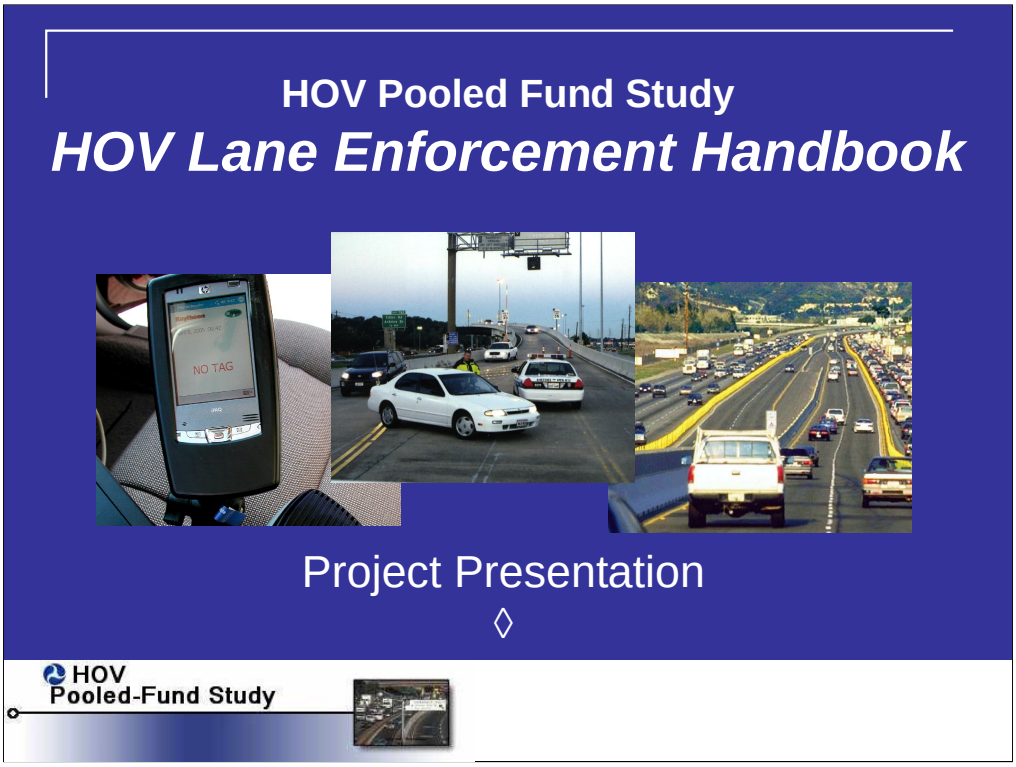
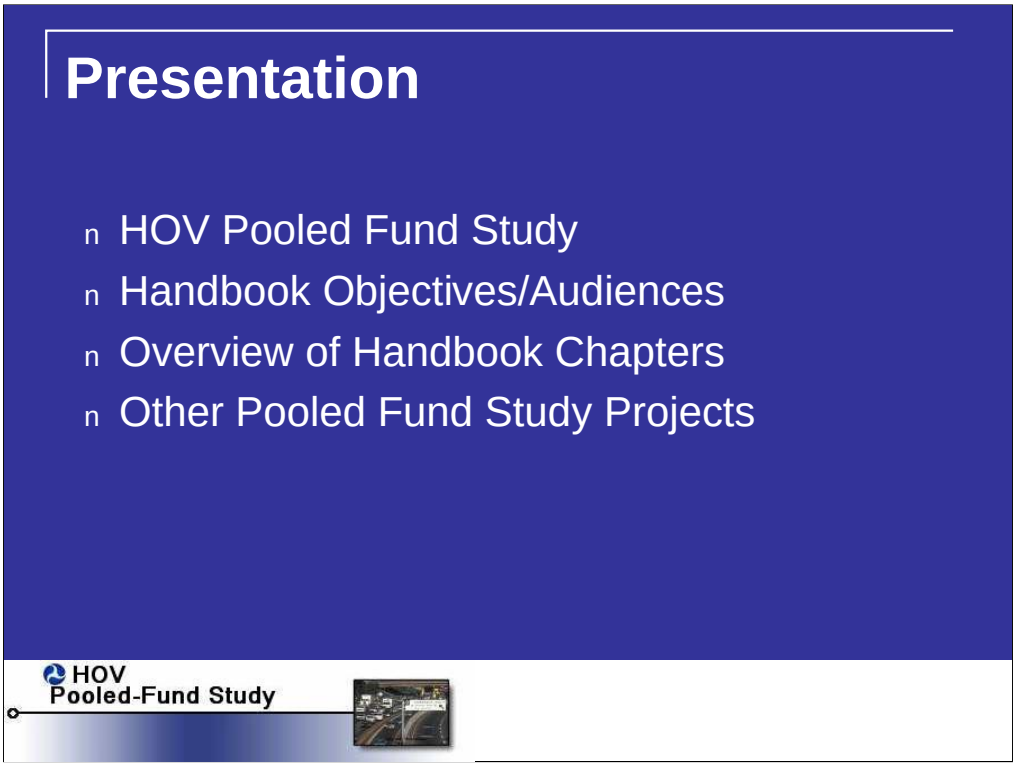
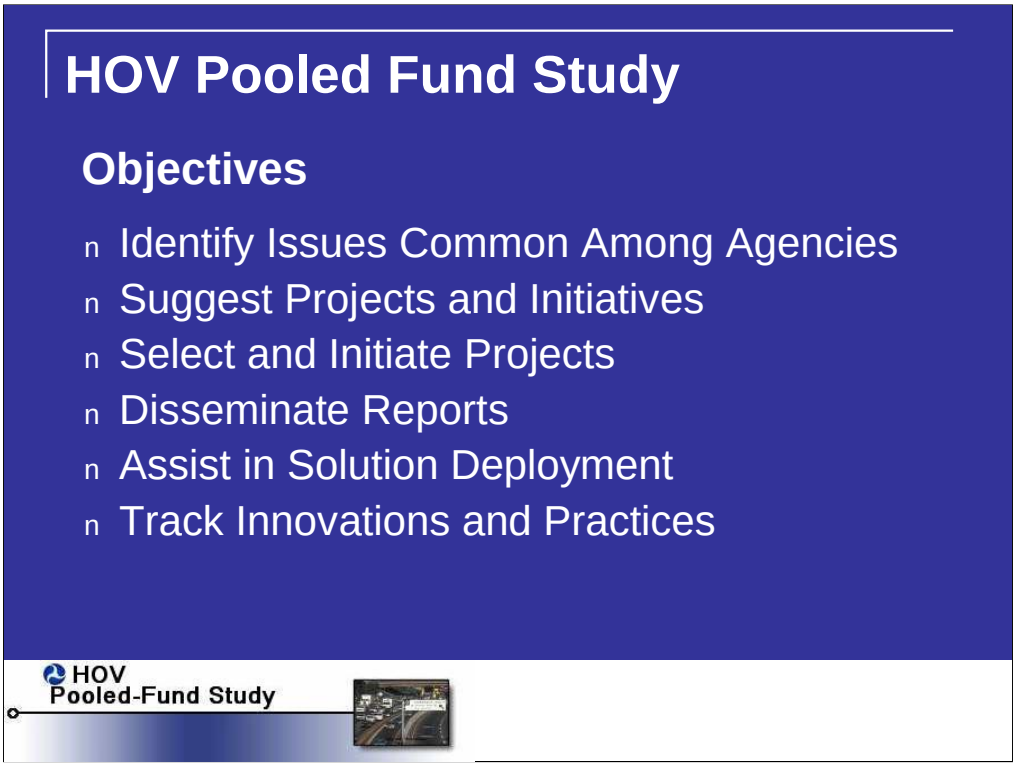


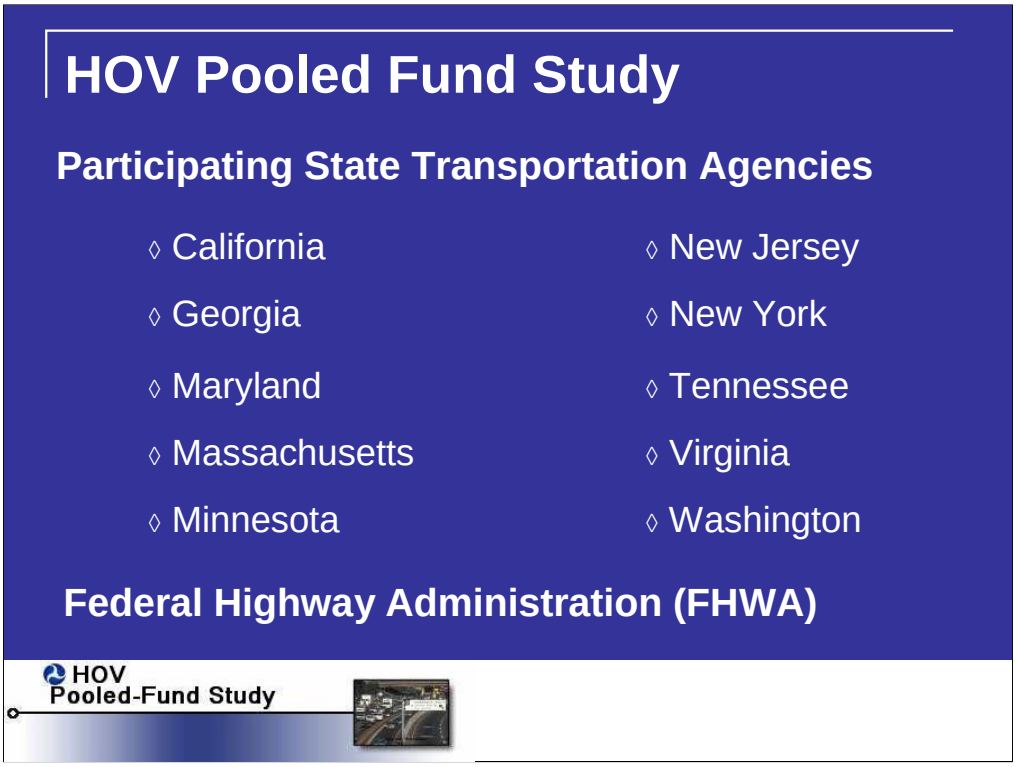
This PowerPoint presentation summarizes the High-Occupancy Vehicle (HOV) Facility Enforcement Handbook developed through the HOV Pooled Fund Study (PFS). It is the longer PowerPoint presentation, which highlights the key elements of the PFS project and covers important topics contained in the handbook chapters. A shorter, less-detailed, PowerPoint presentation describing enforcement considerations of HOV facilities is also available.



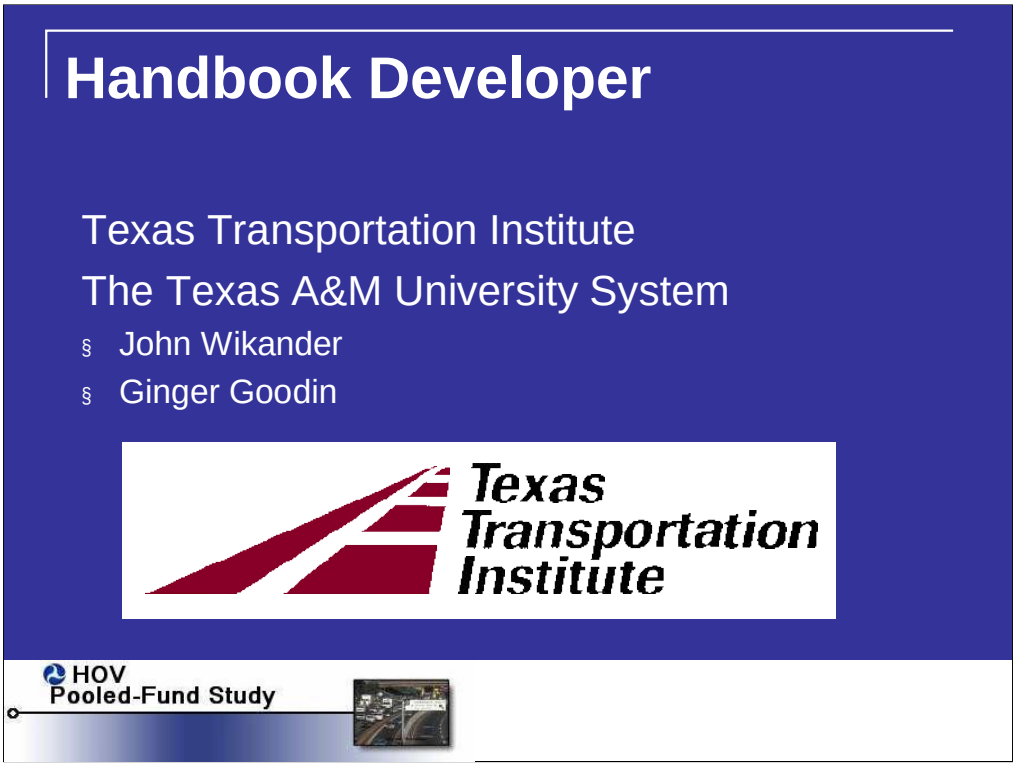
The presentation will cover four major topics. The objectives of the HOV Pooled Fund Study and the participating agencies are described first. Second, the handbook objectives are highlighted, and the audiences for the handbook and related documents are summarized. Third, the handbook chapters are summarized. The presentation concludes by highlighting other projects sponsored by the HOV Pooled Fund Study.



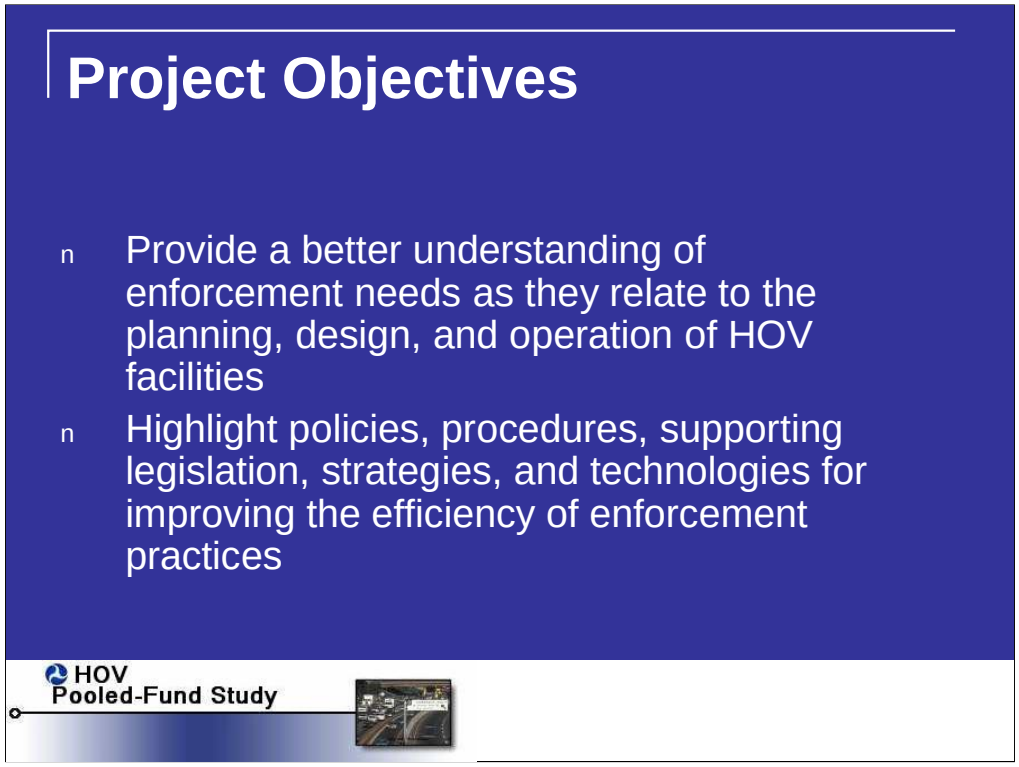
The HOV Pooled Fund Study was undertaken to accomplish a number of objectives. These objectives include identifying common issues related to HOV facilities and suggesting and selecting projects and initiatives to address these issues. Disseminating reports, handbooks, and research results, as well as assisting in solution deployment and tracking innovations and practices represent other objectives.



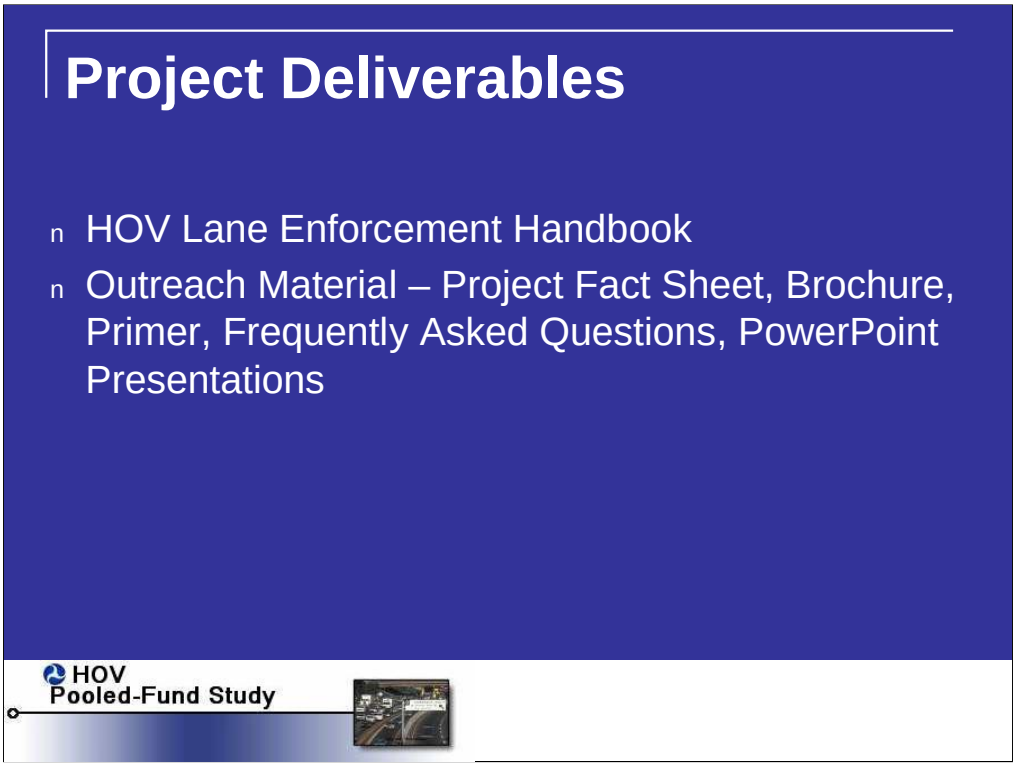
Currently, state transportation agencies in 10 states are participating in the HOV Pooled Fund Study, along with the Federal Highway Administration (FHWA). The 10 states are California, Georgia, Maryland, Massachusetts, Minnesota, New Jersey, New York, Tennessee, Virginia, and Washington. Additional state departments of transportation, public transportation agencies, and other organizations are welcome to join the HOV Pooled Fund Study. Contact information is provided at the end of the PowerPoint presentation for those interested in joining the HOV Pooled Fund Study.



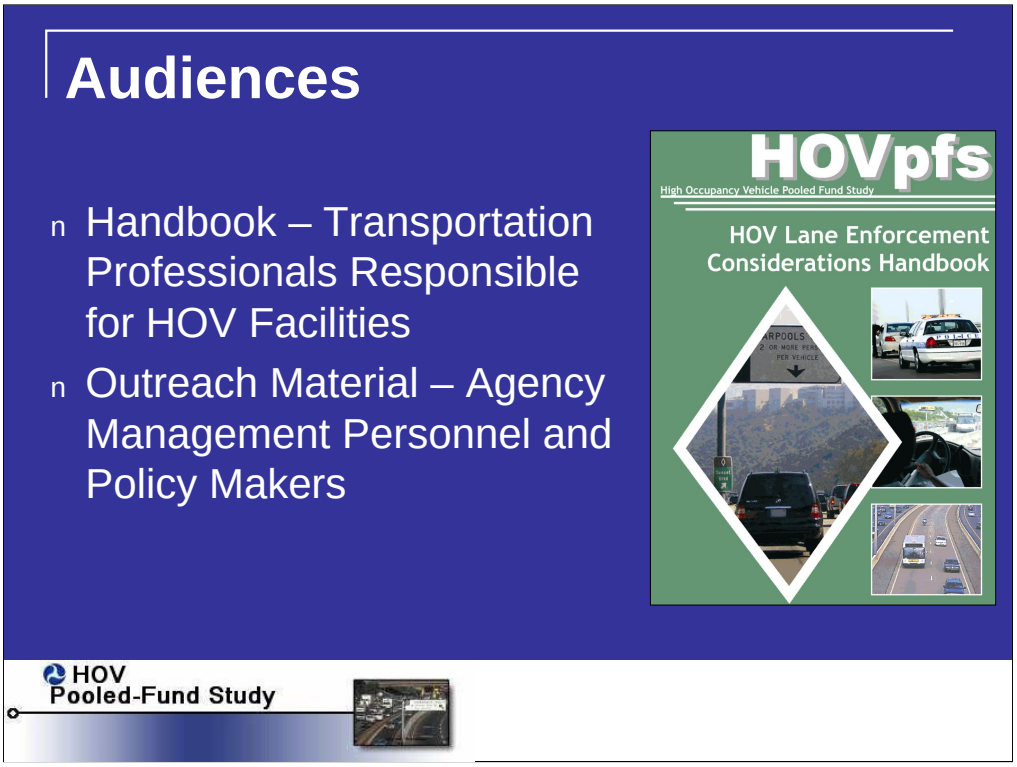
The Texas Transportation Institute (TTI), a part of The Texas A&M University System, was selected to conduct this project through a competitive procurement process managed by the FHWA. Ginger Goodin served as the Principal Investigator on the project and John Wikander was the author of the Handbook.



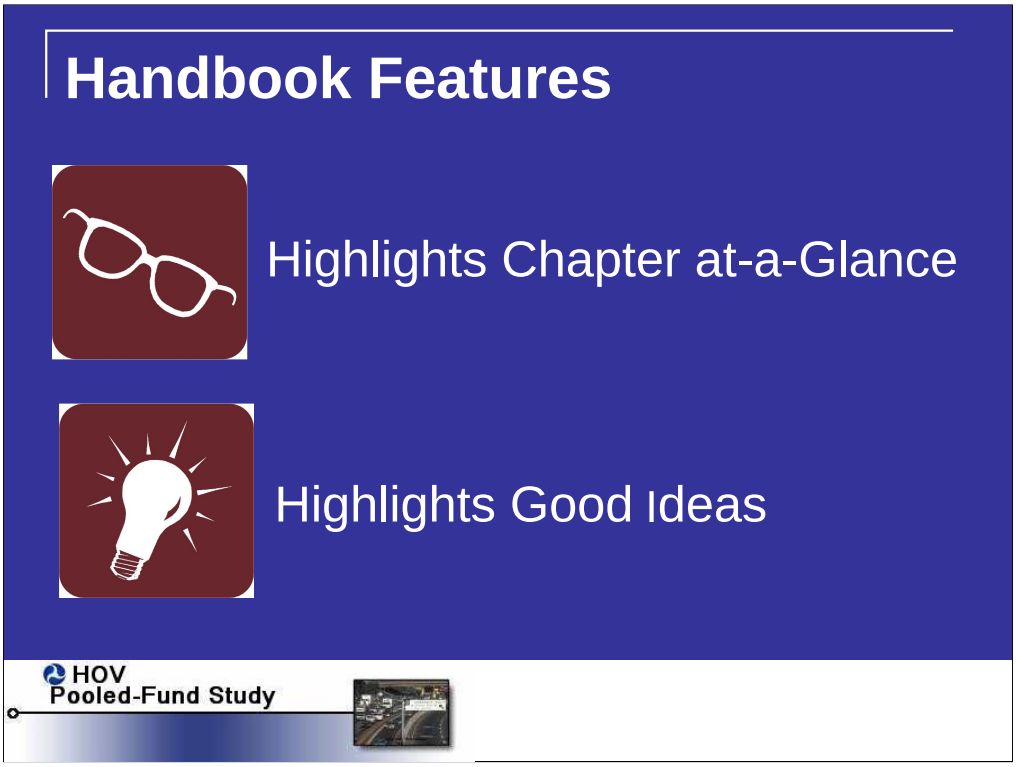
The first objective of this project is to provide a better understanding of HOV enforcement issues and needs through the planning, design and operation of HOV projects. The second objective is to advance the state-of-the-practice by highlighting policies, procedures, legislation, strategies, and technologies that enhance enforcement practices within HOV facilities.



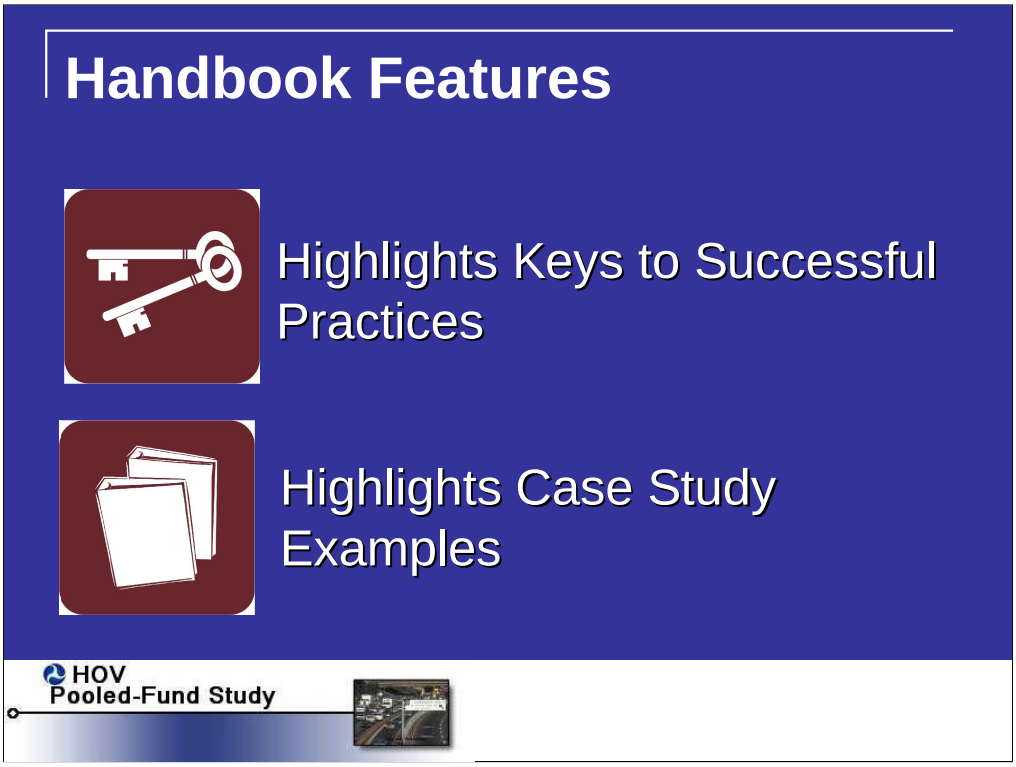
The HOV Lane Enforcement Handbook represents the major product from this project. Outreach materials developed through this project include a project fact sheet, a brochure, a primer, frequently asked questions, and PowerPoint presentations.



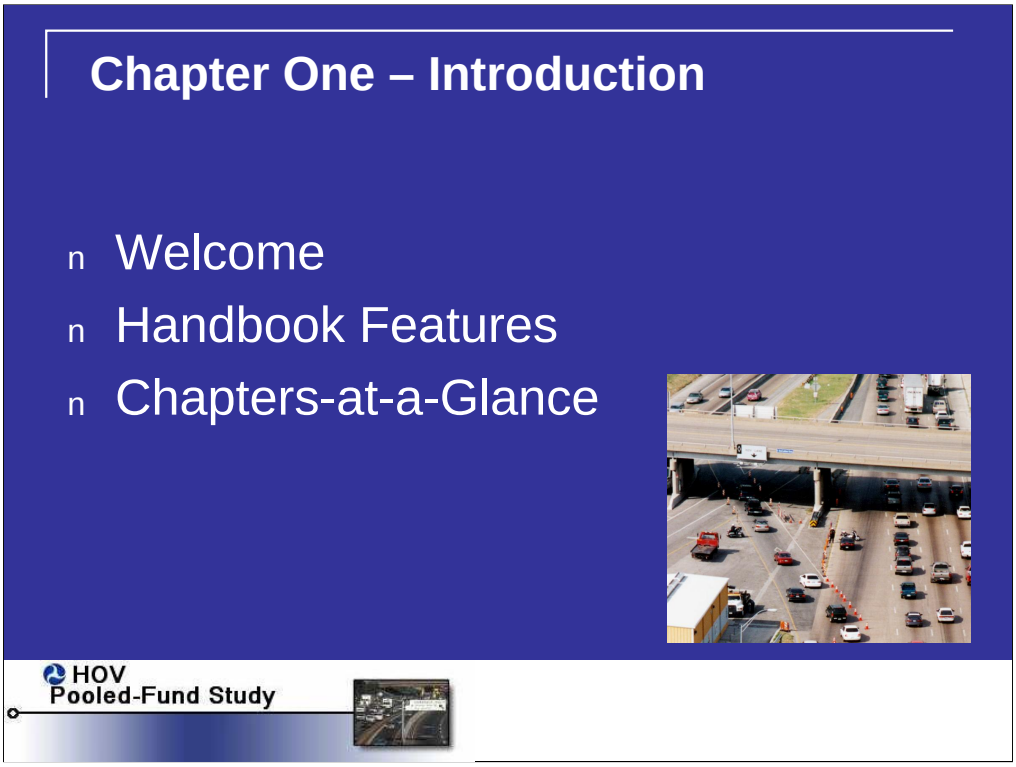
The handbook and outreach materials are targeted toward a variety of audiences and stakeholder groups. The handbook is intended for use by transportation professionals responsible for planning, designing, operating, and traffic enforcement on HOV facilities. The audiences for the outreach materials include agency management personnel and policy makers, as well as other groups interested in the performance of HOV facilities.



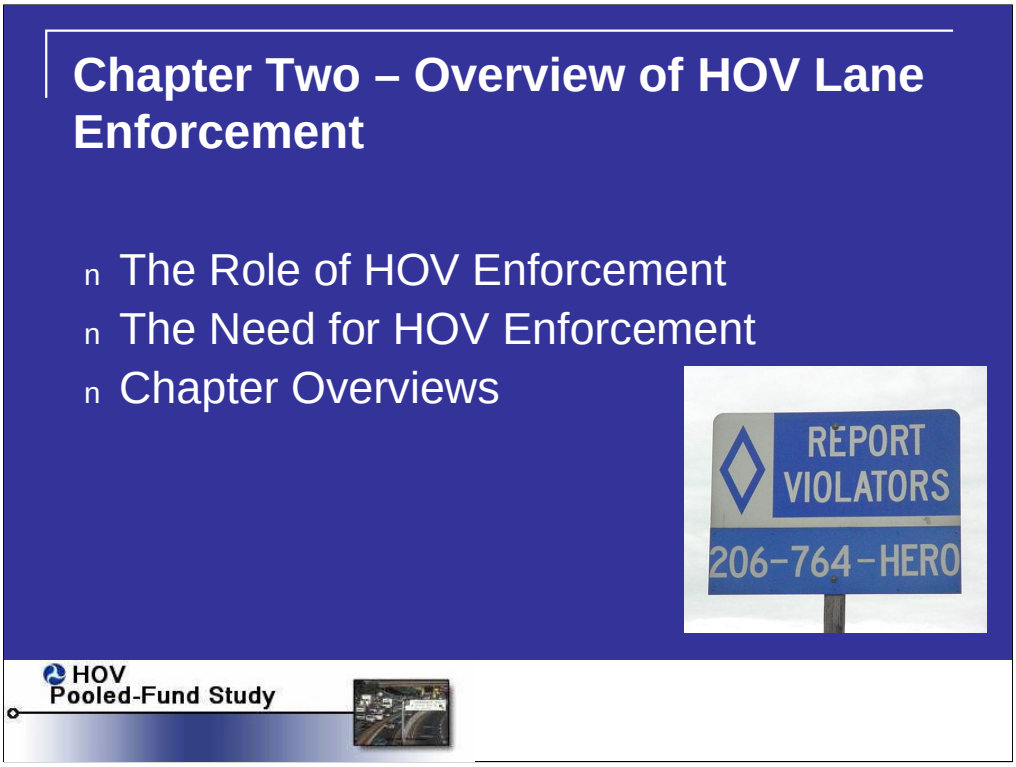
The handbook provides an easy to use guide to HOV enforcement considerations. Icons are used to highlight key points. The eyeglass icons are used to highlight the chapter-at-a-glance at the start of each chapter. The light bulb icon highlights good ideas gleaned from best practice case studies.



The keys icon highlights keys to successful practices. Finally, the notebooks icon highlights case study examples. The case studies in the chapters provide examples to reinforce key points. The case studies in each chapter provide more detailed descriptions of enforcement issues on existing HOV facilities and expand on many of the examples in the chapters.

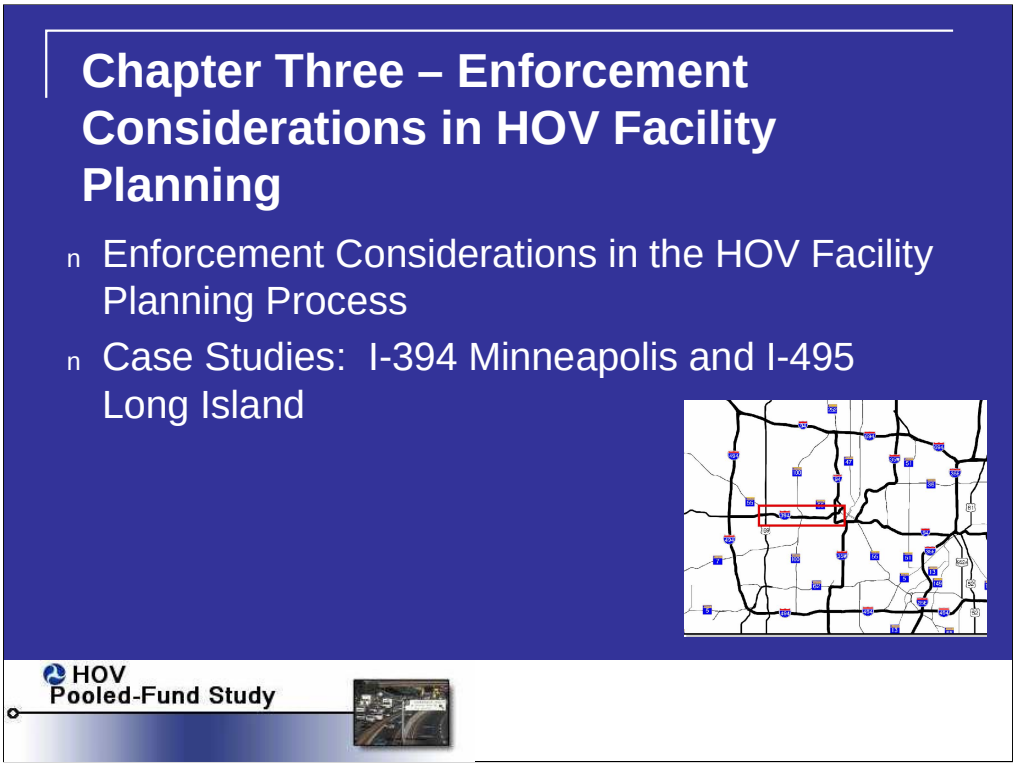


This section of the presentation describes the major topics discussed in each chapter. Chapter One presents the objectives and audiences for the handbook, highlights the use of the four icons, and summarizes the topics covered in each chapter.

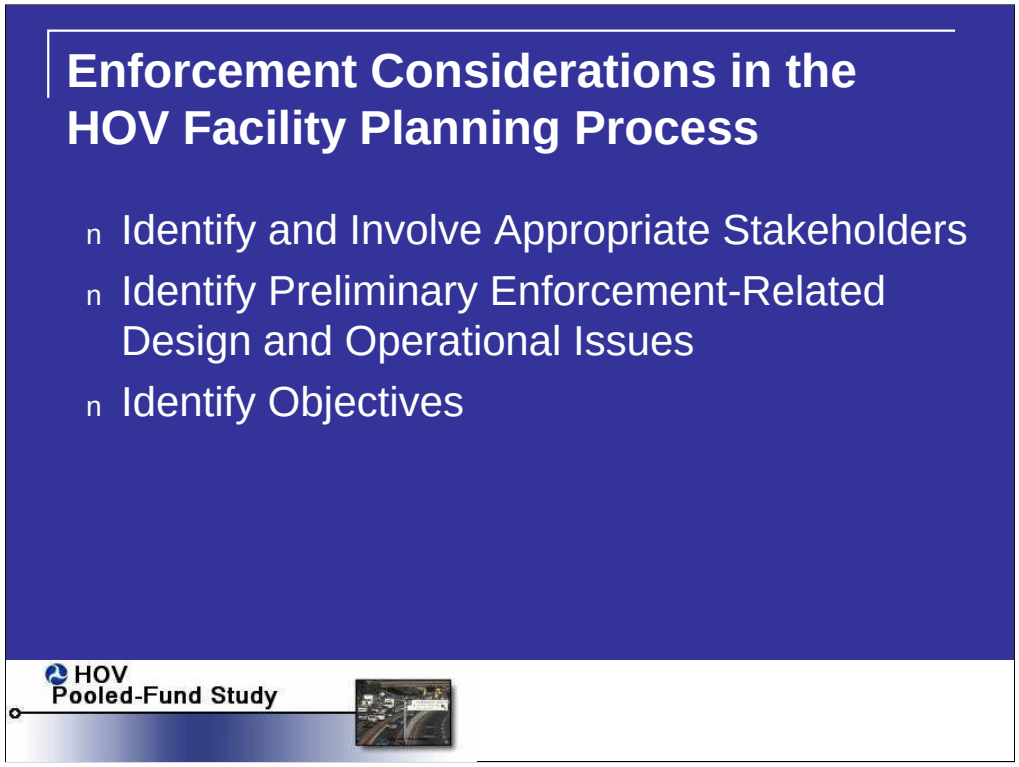


Chapter Two describes the nature of HOV enforcement and identifies factors that create new urgency for effective enforcement, then summarizes the key HOV lane enforcement issues contained in subsequent chapters of the handbook.

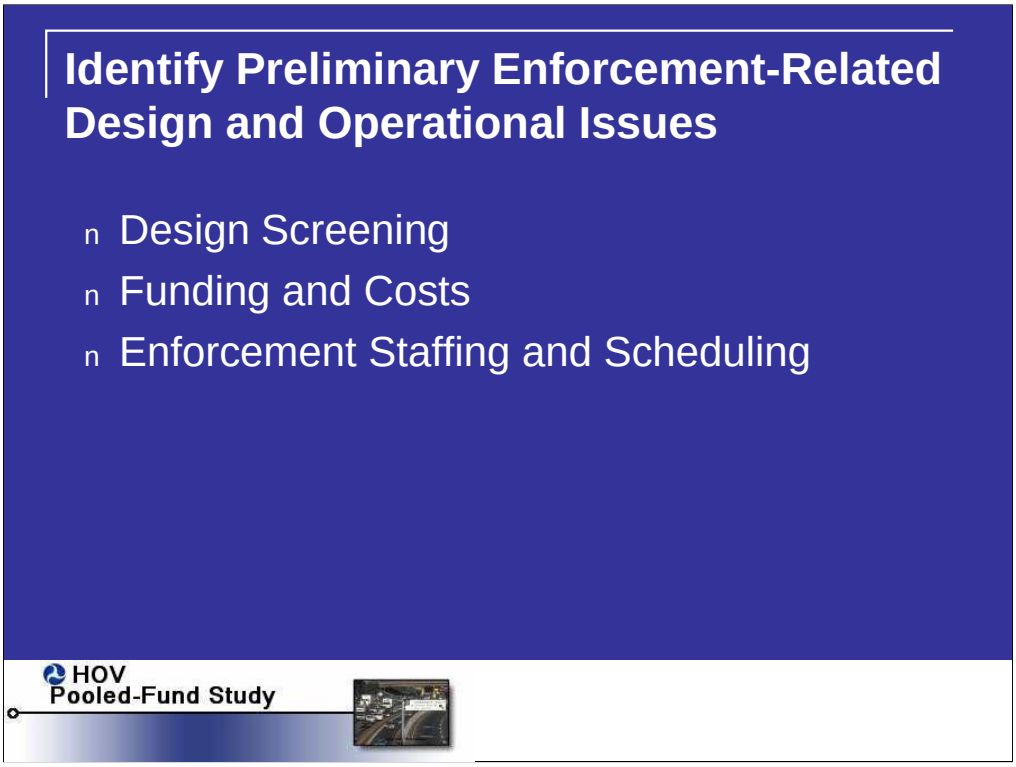
Enforcement is a critical element to the successful operation of an HOV facility. The purpose of an HOV enforcement program is to ensure that operating requirements, including vehicle-occupancy levels, are maintained to protect HOV travel-time savings, to discourage unauthorized vehicles, and to maintain a safe operating environment. Visible and effective enforcement promotes fairness and maintains the integrity of the HOV facility to help gain acceptance of the project among users and non-users. The growing need for effective enforcement has been spurred by both long term and more recent transportation developments. As the nation's highways become increasingly congested, the temptation for non-eligible drivers to cheat and make use of an HOV lane becomes larger. Enforcement agencies increasingly recognize the need for smarter, more efficient strategies to combat violators. More recently, congestion pricing projects, including high-occupancy toll (HOT) lanes, have been implemented. In addition, some states are allowing other forms of exemptions, namely low-emission vehicles, which add a new dimension to the enforcement process. New policies, strategies, and technologies are needed to support the greatly increased complexity of the enforcement task required for such a diverse user base.



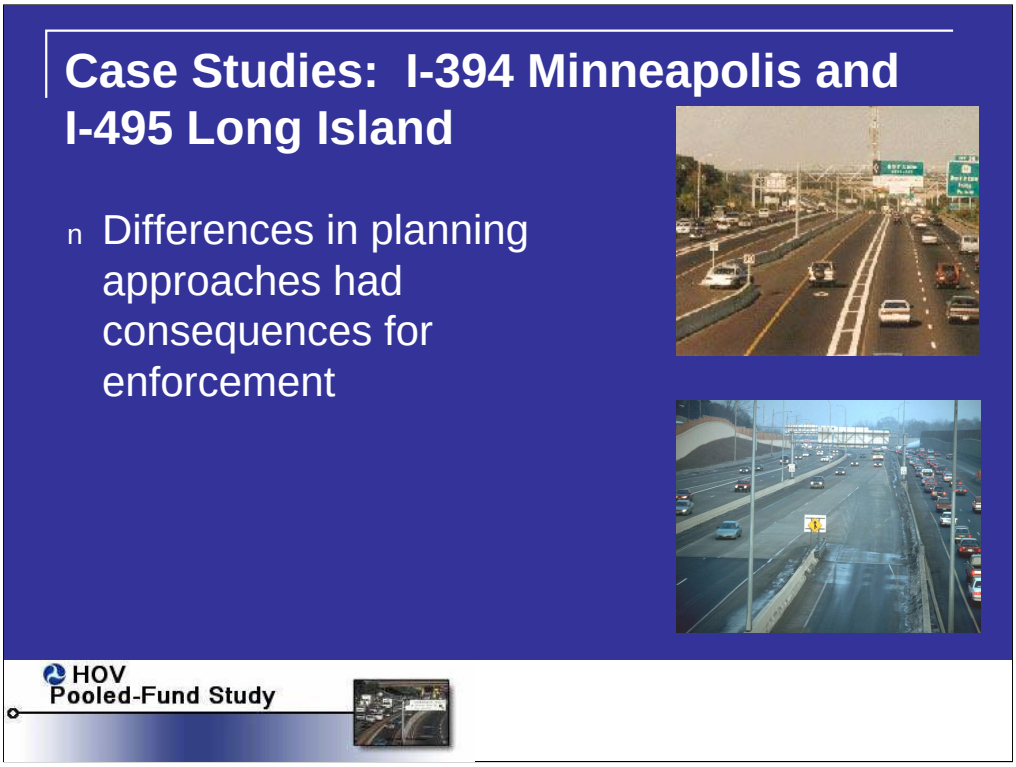
Enforcement issues should be considered at every stage in the creation of an HOV facility. Chapter Three provides an overview of pertinent steps in the facility planning process, noting the role that enforcement considerations should play. This chapter also discusses two facilities, I-394 in Minneapolis, and I-495 on Long Island, and briefly examines the operational results of their respective planning approaches.



Care should be taken to ensure all relevant stakeholders are included in the facility planning process. Depending on the design of the facility, different agencies may have overall project responsibility. No matter which agency takes the lead, state and local police involvement during the planning process will ensure that the needs of enforcement personnel are being addressed and that the facility being planned will be enforceable. Identifying potential enforcement issues related to the design and operation of HOV facilities can serve the interests of both planners and enforcement agencies. Some of the more salient issues are discussed in the next slide. In the context of enforcement, the general overriding objectives in planning an HOV facility are to achieve a low level of violations and a high level of safety. Generally, the target violation rate of 10 percent or less is commonly held as a suitable objective. Violation rates under 5 percent are generally considered "good", while violation rates exceeding 20 percent are regarded as unacceptably high.

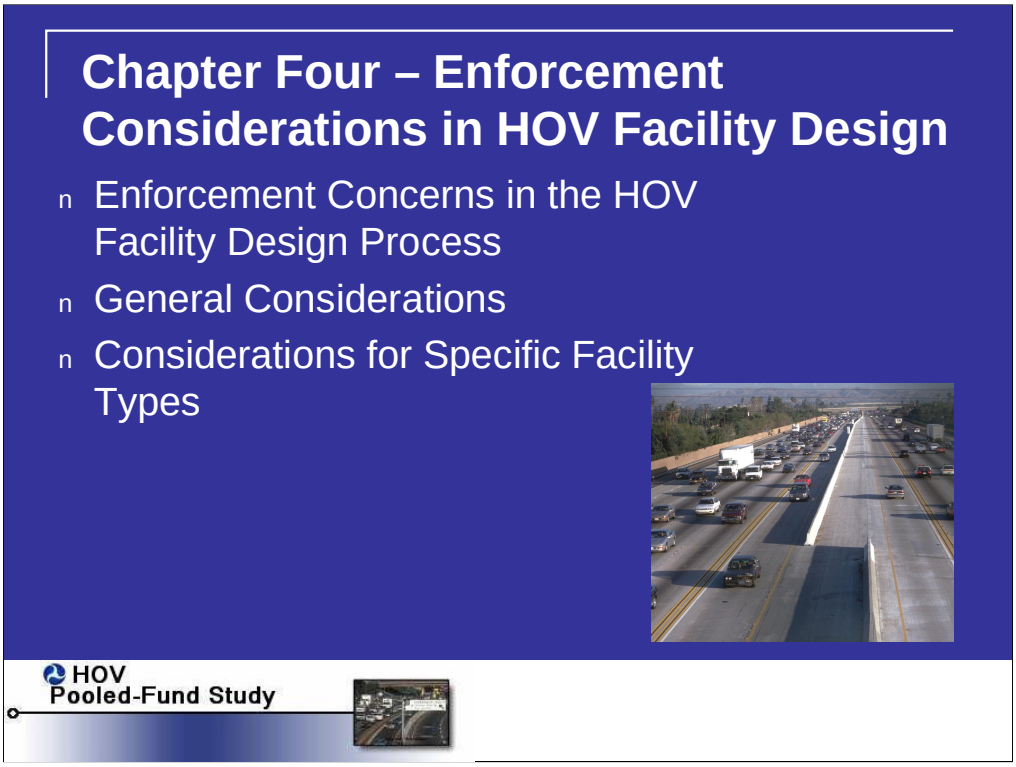


Identifying potential enforcement issues related to the design and operation of HOV facilities can serve the interests of both planners and enforcement agencies. Traffic law enforcement personnel should take an active role in the design screening phase of the planning process. In so doing, they add valuable insight into the nature of possible enforcement problems that may be encountered. Funding for enforcement is another consideration that must be addressed in the planning process. The agency responsible for enforcement will need to consider the financial resources necessary for on-going enforcement. Depending on which agency assumes this responsibility, funding may have to compete with all types of enforcement as well as other, more critical responsibilities of the entire state. The number of enforcement personnel assigned to cover an HOV facility can be highly variable between very similar projects. The level of effort assigned to each HOV project is dependent on many factors, with the most significant ones being facility length, facility operation, the degree to which a facility is conducive to enforcement activities, the types of enforcement strategies, and the availability of enforcement personnel. Enforcement agencies also need to consider institutional and human resource issues when assessing the manpower requirements for HOV enforcement.

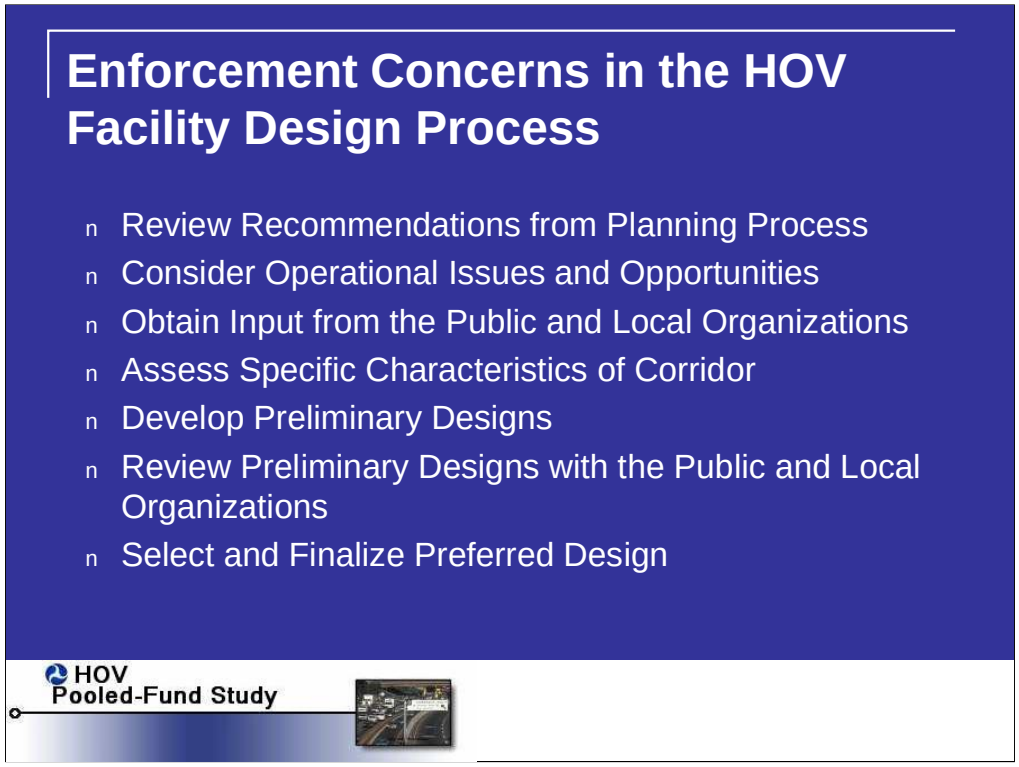


On I-394 in Minneapolis, the section of the HOV project nearest downtown was a two-lane, barrier-separated reversible roadway. Further out the corridor, the HOV facility had transitioned to part-time non-separated concurrent flow lanes. Prior to their conversion to HOT operation in 2005 as the MnPASS I-394 Express Lanes, the HOV lanes on I-394 were underutilized and suffered from excessive occupancy violations. The I-495 HOV-lane system is a two way buffer-separated concurrent flow facility. At a number of locations, access between directions for enforcement vehicles is provided via a slip ramp break in the concrete median barrier. Peak period occupancy violation rates are approximately 5 percent on this facility, based on occupancy counts last taken in 1999.

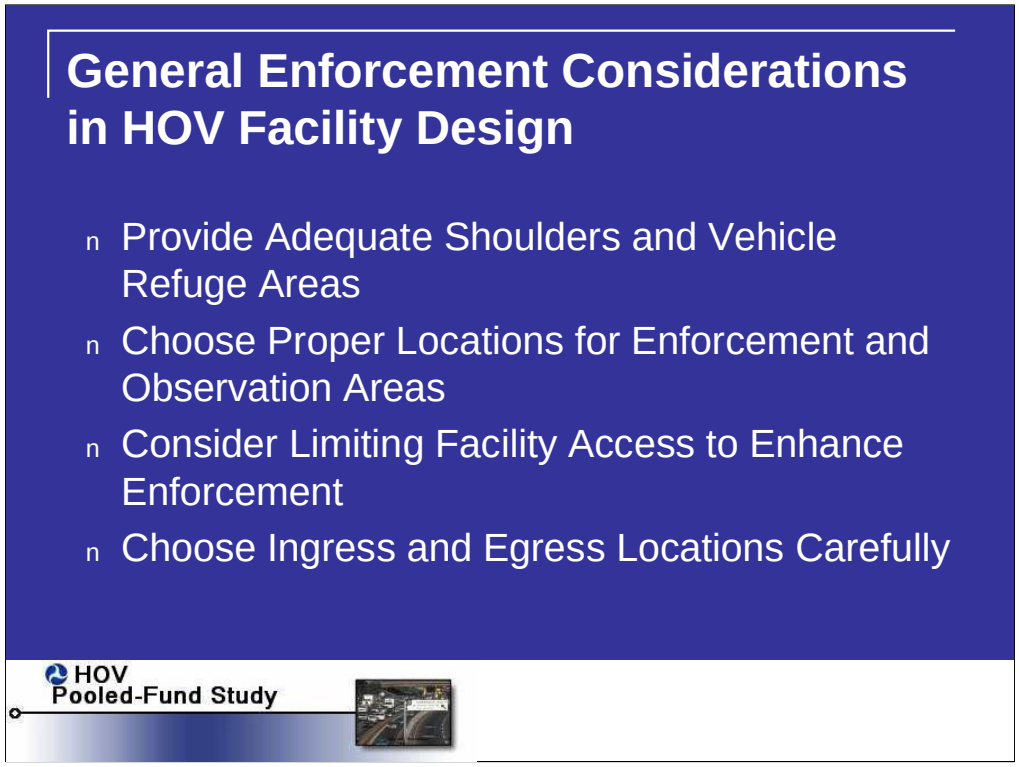
Many of the enforcement deficiencies experienced on the I-394 HOV facilities can be traced to the planning and design phases of the project. Enforcement agencies were not successful in their efforts to have additional desired enforcement elements incorporated into the facility design. The planning process for the I-495 HOV lanes benefited from the active involvement and input from enforcement agencies. When the planning for HOV-lane operation was begun, an HOV Task Force discussed at length many enforcement issues including the types of enforcement strategies that may be employed.



This chapter provides an analysis of enforcement considerations in HOV facility design. Enforcement concerns are noted as they relate to the design process outlined in the NCHRP *HOV Systems Manual*, and enforcement considerations pertaining to different types of HOV facilities are addressed.



The design process for HOV facilities involves a number of steps, beginning with a review of the recommendations from the planning process and continuing to the selection of the final preferred design. This slide notes the enforcement-related design issues present at the various steps in the design process. At the initial stage of the design process, the results or recommendations from the planning process are considered. Reviewing the operational issues and the opportunities related to the selected HOV alternative can assist in identifying critical enforcement elements that may need to be addressed in the project design. Detailed assessments of corridor characteristics should be conducted to identify any significant constraints on enforcement effectiveness, such as available right-of-way, intersection spacing, topographical contours and profiles, and corridor bottleneck locations. Planners and project designers, in cooperation with enforcement agencies, should estimate the potential impact of each preliminary design alternative upon enforcement operations. The preliminary designs should be reviewed by the public, business and neighborhood groups, and other organizations along the freeway or corridor. Public education efforts to describe the basic enforcement parameters of the HOV project should be developed at this step, and essential details of the enforcement program should be transmitted. The design can then be finalized and used to develop the plans and specifications for the project, and the actual construction and implementation process initiated. Once the preferred HOV design concept has been selected, a comprehensive enforcement program should be developed.



Some key general enforcement considerations should remain foremost throughout the facility design process. Adequate shoulders and vehicle refuge areas ensure that HOV lanes can be safely and efficiently enforced. Locations for enforcement and observation areas should be situated so that officers have a safe vantage point to easily observe vehicles, and which provide good lighting for viewing vehicle interiors. The number of access points along a HOV facility contributes to the ease or difficulty with which the facility can be enforced. Facilities with more limited access, such as barrier separated facilities, are generally easier to enforce than non-separated concurrent flow lanes. For limited access facilities, ingress and egress locations should be designed to meet the traffic demand but should also be upstream of likely bottleneck locations on the general-purpose lanes, to prevent conflicting weaving maneuvers by HOV and general purpose lane traffic in congested conditions.

Design Recommendations for Dedicated Enforcement Areas

Design Feature	Low-Speed Enforcement Areas	High-Speed Enforcement Areas
Locations	Access points along barrier-separated facilities, such as ramps, reversible lane entrances, and queue bypasses	Spaced every 3.2 – 4.8 km along the mainline HOV facility
Length	30 – 60 m (100 – 200 ft)	30 m (100 ft) for monitoring only 394 m (1300 ft) for monitoring and apprehension
Shoulder Width	3.6 – 4.3 m (12 – 14 ft)	4.2 – 4.5 m (14 – 15 ft)
Approach Taper	2:1 or 9.1 m (30 ft)	At least 20:1
Departure Taper	10:1 or 45.7 m (150 ft)	At least 80:1

HOV Pooled-Fund Study

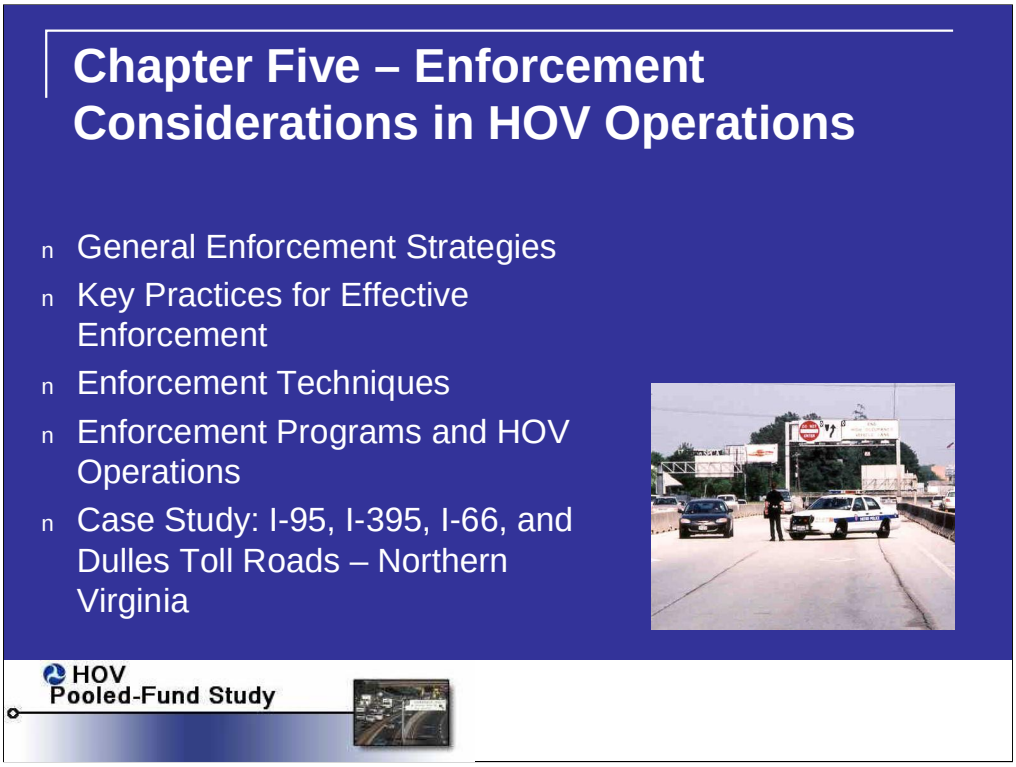
The term "enforcement area" is used to refer to a number of potential design treatments that provide space for police personnel to monitor an HOV facility, to pursue a violator, and to apprehend a violator and issue a citation. Two general classifications for enforcement areas are often used. Low-speed enforcement areas are usually located at access points on barrier-separated HOV projects. Specific locations may include ramps, reversible lane entrances, and queue bypasses where vehicle speeds are relatively slow, usually below 75 km/hr (45 mph). Low-speed enforcement areas are often designed to provide for monitoring, apprehension, and citing of violators, and where practicable, violator removal from the HOV facility. High-speed enforcement areas are recommended if an HOV lane includes a number of at-grade access locations with speeds at or above 75 km/hr (45 mph), or lacks continuous shoulders wide enough for enforcement. These areas are usually designed either for monitoring traffic or for monitoring and apprehending violators, and are spaced periodically along the facility. For either application, police personnel often prefer that periodic enforcement areas be designed in conjunction with full outside shoulders or full outside buffers.

Enforcement Design Considerations for Specific Facility Types

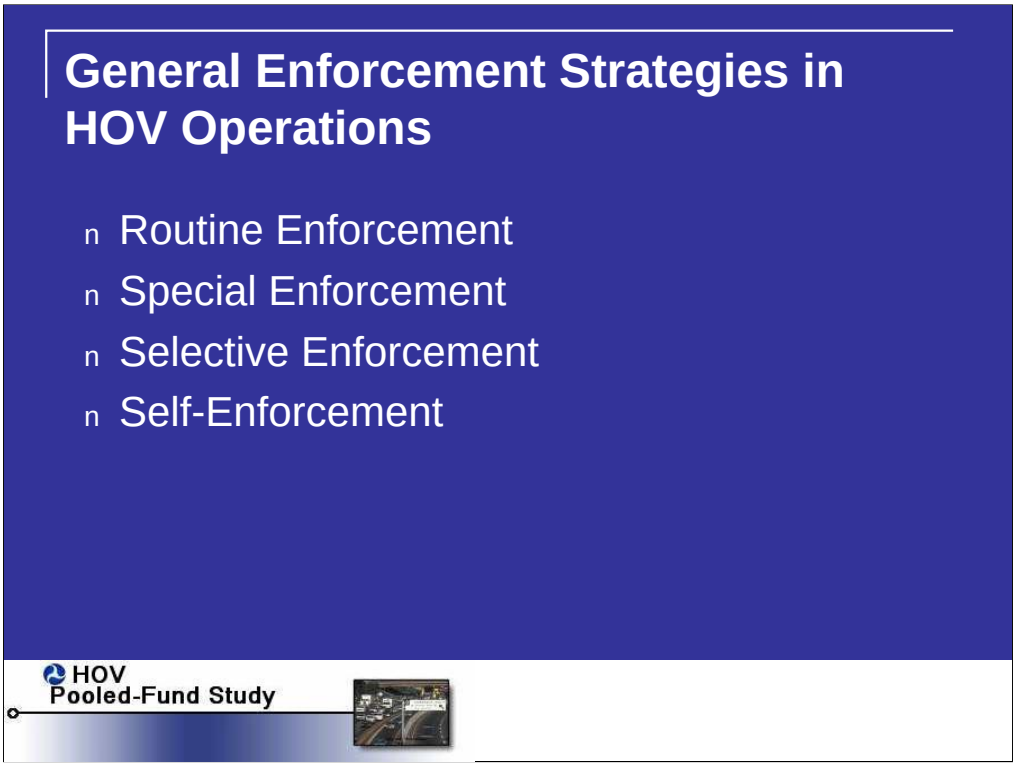
Facility Type	Preferred Enforcement Features	Minimum Enforcement Features
Barrier-Separated	Enforcement areas at entrances and exits Continuous enforcement shoulder	Enforcement areas at entrances or exits
Concurrent Flow	Continuous median enforcement shoulders with periodic barrier offsets Continuous right-side buffers	Periodic mainline enforcement areas Monitoring areas Continuous right-side buffers
Contraflow	Enforcement area at entrance Continuous inside shoulder	Enforcement area at entrance
Queue Bypass	Enforcement area on right-side shoulder Continuous right-side shoulder Duplicate signal head facing enforcement area at ramp meters	Enforcement monitoring pad with continuous right-side shoulder downstream

HOV Pooled-Fund Study

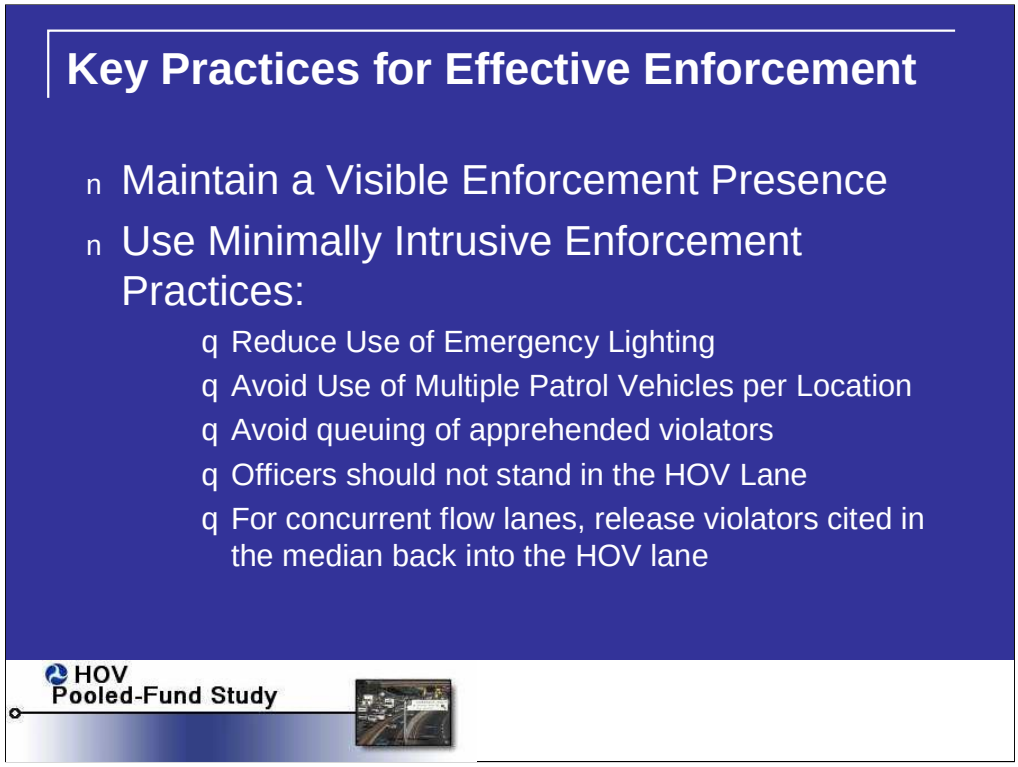
The ease or difficulty associated with enforcement will be related to the type of HOV facility and specific issues in the area. Barrier-separated lanes act as a deterrent to potential misuse, as violators are trapped in the lanes with few options to evade detection. The geometric requirements for a reversible facility provide enforcement pockets within the ramps that can serve as low-speed enforcement areas for the opposing direction. Two-way facilities require an enforcement shoulder if mainline enforcement is desired, as there are no unused elements of the HOV lane roadway in which enforcement vehicles can perform their operations. Adequate space for median shoulders on concurrent flow facilities is tremendously important. A sufficient length should be provided to pull over a violator and, once cited, allow the violator to safely reenter the traffic stream. Full painted buffers should be provided to enhance separation between the HOV lanes and general-purpose lanes. Contraflow HOV lanes typically include a single entrance area and a single exit. Enforcement areas are positioned at the upstream entrance to the contraflow lane to monitor and enforce lane operations, and prevent wrong-way maneuvers. A continuous inside shoulder is recommended to provide refuge for vehicle breakdowns. Queue bypass HOV lanes which are physically separated from the general lanes enhance enforcement and safety, by eliminating possible interaction between HOVs and general traffic. An optional ramp meter signal status indicator which faces the enforcement area may be placed at the HOV bypass.



Chapter Five focuses on HOV-lane operations and the development of enforcement policies and programs. The chapter discusses the components of an enforcement program which pertain to HOV facility operation. Examples from selected case studies illustrating the concepts presented can be found throughout the chapter.



Enforcement strategies for HOV facilities can generally be categorized into the four basic approaches. Routine enforcement represents the normal level of police patrols in an area, irrespective of the presence of an HOV facility. Special enforcement is characterized by continuing, systematic manpower allocations and enforcement tactics specifically dedicated to enforce HOV violations. A special enforcement strategy is appropriately employed when the need for HOV enforcement is great. Selective enforcement strategies seek to induce a high level of motorist compliance by applying routine and special enforcement strategies in an unscheduled manner, thereby not allowing motorists to predict when enforcement will occur. Self-Enforcement involves self-regulation by HOV lane users and motorists in the general-purpose lanes. Self-enforcement is usually used with other approaches, rather than as the only enforcement strategy.



Irrespective of the particular strategies or techniques employed, certain general practices have been shown to enhance the effectiveness and safety of enforcement activities. Enforcement efforts have greater deterrent effect if they are visible to other motorists. Police personnel should conduct apprehensions and issue citations in designated enforcement areas adjacent to the HOV lane. HOV violators should not be removed to other areas of the freeway for ticketing unless there is no room along the facility for safe conduct of these activities.

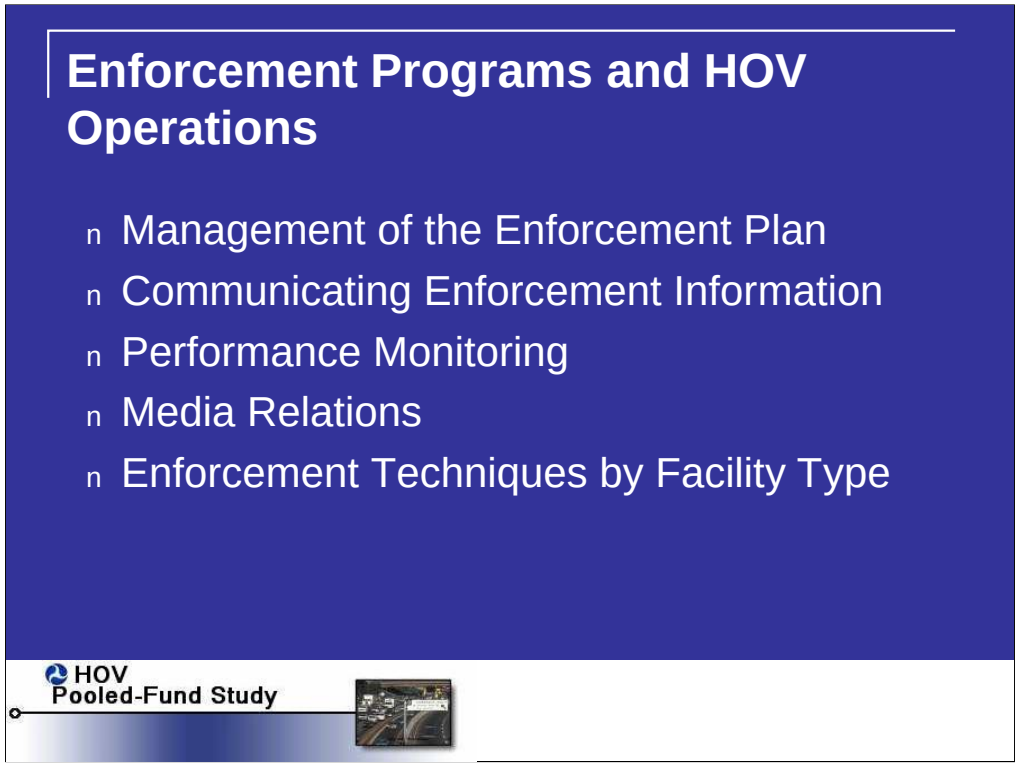
Although visible enforcement is desirable, heavy enforcement can be disruptive to traffic as it usually induces rubbernecking. The minimally intrusive enforcement practices listed here should be used to reduce possible traffic disruptions.

Enforcement Techniques

Enforcement Technique	Advantages	Disadvantages
Stationary Patrols	No pursuits required Greater safety for wide facility cross sections Highly visible enforcement presence Effective for monitoring and apprehension	Requires diversion of personnel Limited to certain locations May be circumvented on facilities with many access locations
Roving Patrols	Can operate anywhere No reallocation of personnel	Longer apprehension times Disruptive without refuge areas Less favorable for observation
Team Patrols	Separates detection and apprehension tasks Greater flexibility for geometrically constrained facilities	More manpower per apprehension Not supported if apprehending officer must also witness violation
Electronic Monitoring	Minimal manpower requirements Unobtrusive	Current technology less reliable than visual inspection
Citations or Warnings by Mail	Safer since no apprehensions Smaller refuge areas required Highly time efficient	Currently not supported in law Officers cannot conclusively verify violations without apprehension

HOV Pooled-Fund Study

A variety of enforcement techniques can be used to monitor HOV facilities to enhance compliance. Although no one enforcement technique equates specifically to one type of HOV facility, some approaches may be more appropriate for consideration with certain HOV projects. Stationary patrols involve the assignment of enforcement personnel at specific locations along an HOV facility. These may be dedicated enforcement areas or locations that provide the necessary vantage points and space for enforcement personnel. Roving Enforcement Patrols involve enforcement vehicles patrolling the length of the HOV facility, either on the HOV facility or on the adjacent freeway. Team Patrols are various combinations of stationary and roving patrols working in unison to monitor an HOV facility and to apprehend violators. The team approach is generally utilized on HOV projects when it is impossible, or considered unsafe, for a single officer to detect and apprehend a violator. Electronic monitoring and citations or warnings by mail may be used by enforcement personnel if they have been granted the legal authority to do so. This eliminates the necessity of stopping a vehicle violating the HOV requirement. The violators may be observed by police officers on the spot or with the aid of cameras and other advanced technologies. Due to successful legal challenges, however, no provisions for issuing citations by mail are currently in effect with HOV facilities.



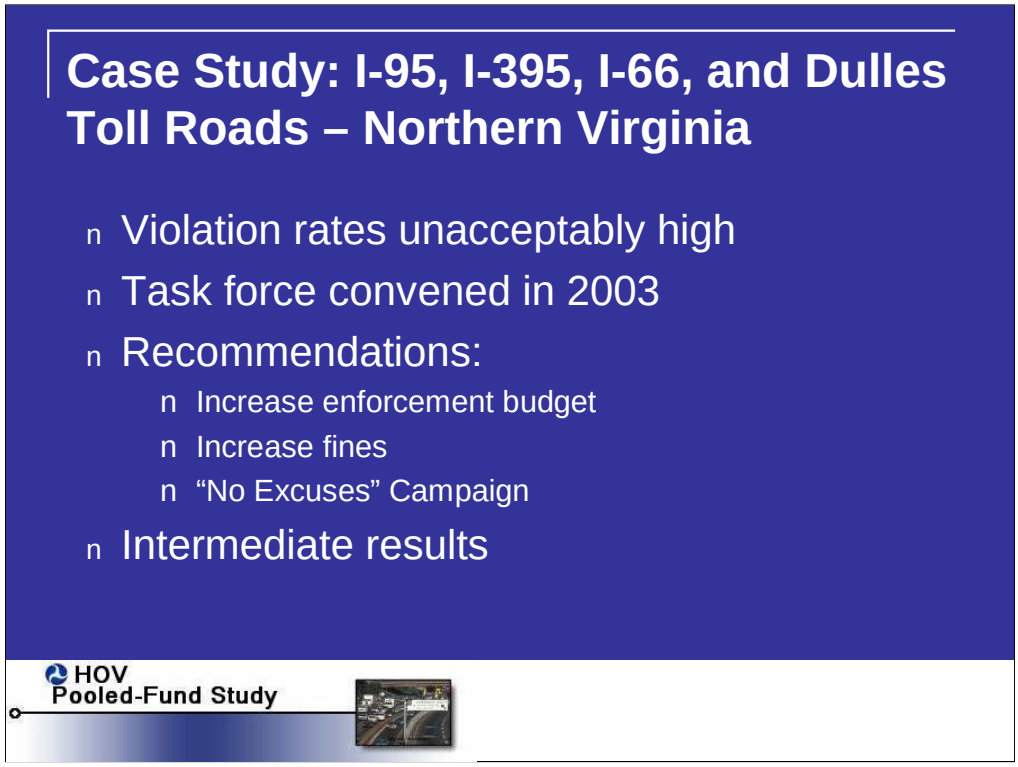
This slide considers some of the issues that may need to be considered in developing enforcement programs for various types of HOV lanes. A detailed enforcement manual is highly recommended for effectively managing a complex HOV enforcement program. This manual should provide descriptions on the HOV project, system operations, enforcement procedures and reference information. A detailed enforcement manual will reduce the chances of misunderstandings among project personnel, enforcement officers in the field and enforcement agency management personnel as to the functions and responsibilities of each group. Performance monitoring programs provide the ability to determine if the goals and objectives of an enforcement program are being achieved. Such a monitoring program is required to determine compliance levels, provide a basis for fine-tuning enforcement operations, and identify problems that may need to be addressed. Evaluations may also be needed to meet federal or state requirements. Public awareness is essential in any new enforcement program. Enforcement agencies uniformly concur that a public awareness program which notifies the public of enforcement activities increases the effectiveness of the enforcement effort. Media relation activities, such as press releases and press conferences, editorial board and assignment editor briefings, and media tours, can be used to heighten awareness and increase visibility of the enforcement program. Radio and television talk shows dealing with news, features, or special segments may also be appropriate communication mechanisms. Enforcement techniques are discussed in the next slide

Enforcement Techniques by Facility Type

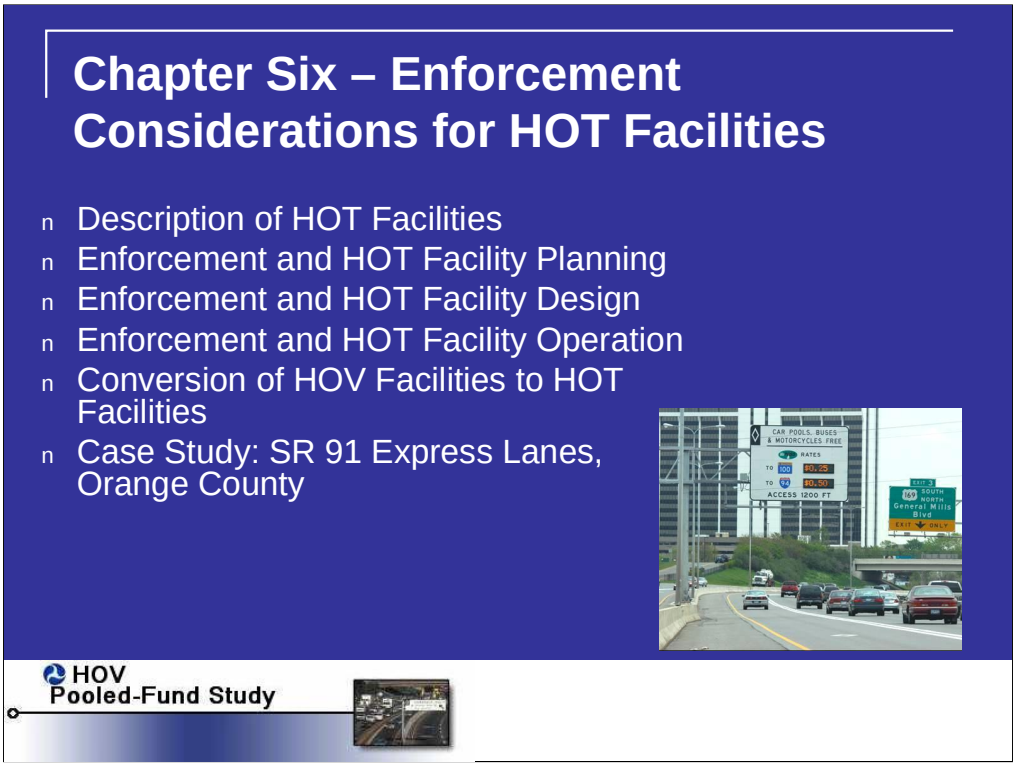
Facility Types	Enforcement Techniques
Barrier-Separated	Stationary patrols at beginning or end of lane Team patrols Multipurpose patrols Self Enforcement
Concurrent Flow	Stationary patrols at enforcement enclaves Roving patrols Team patrols Multipurpose patrols Self Enforcement
Contraflow	Stationary patrols at beginning or end of lane Multipurpose patrols Self Enforcement
Queue Bypass	Stationary patrols at ramp entrance Self-enforcement

HOV Pooled-Fund Study

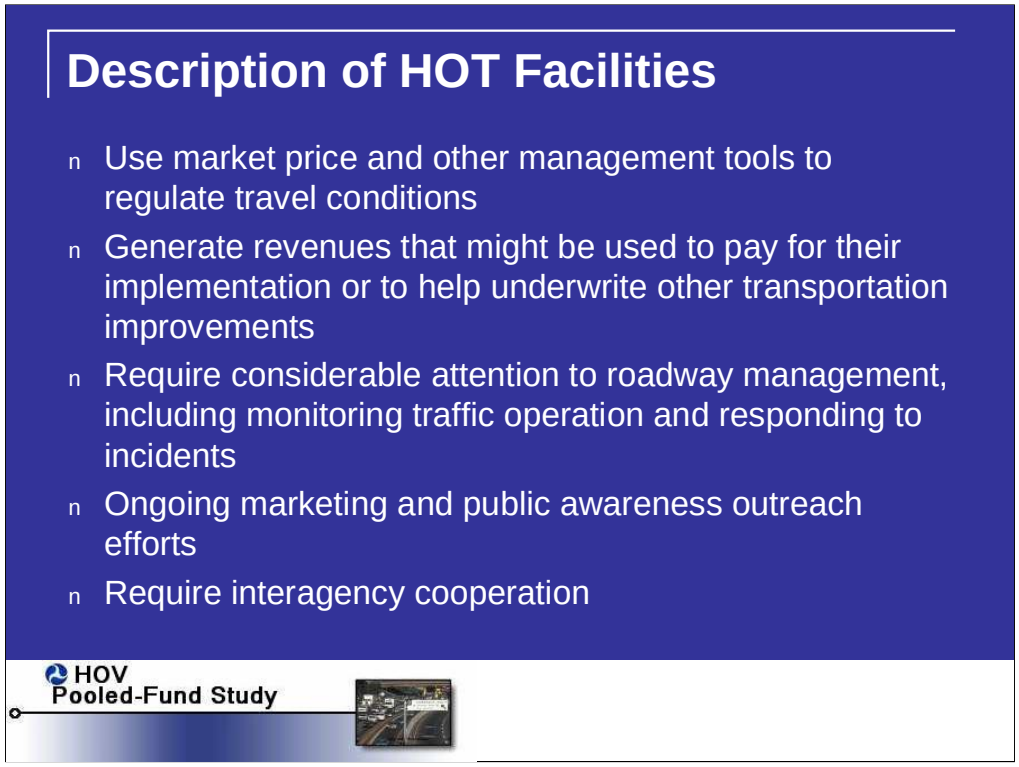
Barrier-separated HOV facilities are easier to enforce due to limited ingress and egress and the physical separation from the general-purpose lanes. Stationary patrols, team patrols, and multipurpose patrols may all be appropriate for consideration with exclusive HOV lanes. Enforcement areas can be provided at direct access ramps, and at the beginning and end of a facility. The use of team enforcement, with one officer located at the beginning or mid-point of a facility radioing information on violators to an officer at the end of the facility where the apprehension takes place, can be an effective technique. Concurrent flow HOV lanes require extra consideration and increased enforcement. Selective enforcement using roving and team patrols, in combination with standard apprehension and citation procedures, are used with many concurrent flow facilities. Ensuring that safe and adequate enforcement areas are provided is also critical with the type of facility. Contraflow HOV lanes are often easier to enforce because of limited access —often just a single entrance and exit —and because of limited vehicle eligibility criteria. Enforcement personnel are usually stationed at the beginning and/or end of a lane, and violators can be stopped at these points. Techniques for enforcing queue bypasses are limited to a stationary enforcement area. Violations mainly occur where there is a clear view of the ramp and, therefore, violators are able to tell if enforcement activities are taking place. Enforcement may be made more unobtrusive and effective by screening enforcement vehicles from the view of oncoming motorists.



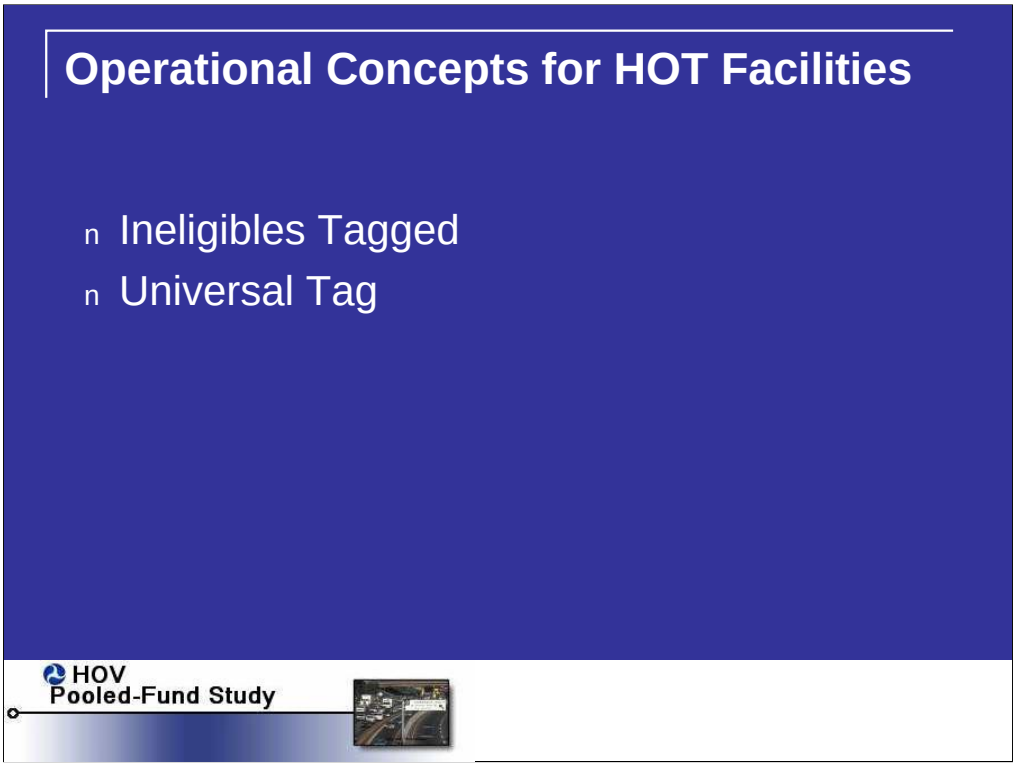
The I-95, I-395, I-66, and Dulles Toll Road HOV lanes serving northern Virginia are the focus of a six-year effort to substantially reduce HOV violations. Increasing congestion and complaints of widespread cheating prompted the Virginia Department of Transportation to convene a HOV Enforcement Task Force in 2003 to find and recommend solutions to improve enforcement. The task force recommended tough countermeasures, such as increasing the $140,000 enforcement budget by an additional $250,000 for extra enforcement; increasing fines for HOV violations up to $1000 for fourth and subsequent violations, and launching a "No Excuses" public information campaign. Once the campaign began, special and selective enforcement were used during the morning peak periods to target problem locations. Over 18,000 citations had been issued in the 17 months until the next meeting of the HOV Task Force in January 2005. The Task Force found that the stepped up enforcement had reduced overall violation rates during the morning periods somewhat but had mixed results with respect to reducing the number of early morning violators. Stepped up enforcement will therefore continue for the foreseeable future.



HOT facilities have unique enforcement issues. The issues addressed in the chapter supplement the HOV-lane enforcement presented in previous chapters. In particular, implementation approaches and issues encountered in converting HOV facilities are examined and are the focus of the case study.

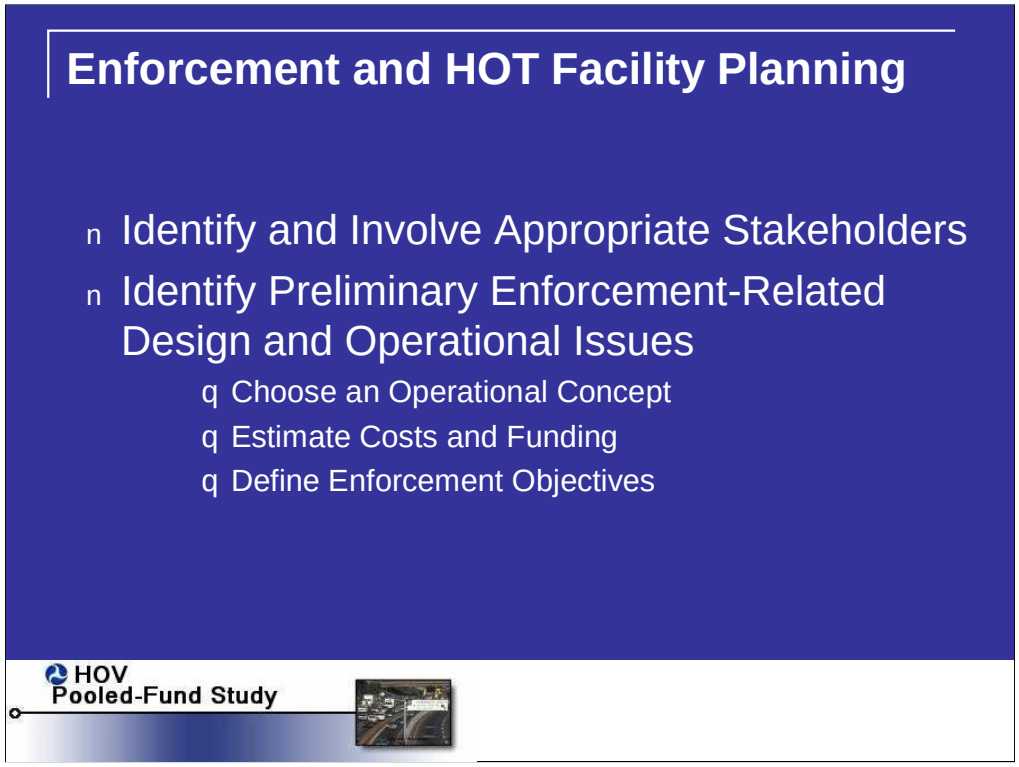


High Occupancy Toll (HOT) lanes are HOV lanes that allow lower occupancy vehicles to have access to the facility for a toll, essentially "selling" unused capacity in the HOV lane. The revenue from toll operations may be used for repaying implementation costs, funding ongoing operations, and financing other transportation improvements. HOT lanes utilize traffic management techniques in new ways, and in many jurisdictions HOT lanes may involve the introduction of tolls for the first time. They may also introduce non-traditional project financing and operational approaches. Most importantly, they introduce public relations challenges that have the potential to bring HOT lane initiatives to an abrupt halt at nearly any stage of their development. New legal and institutional structures and operational capabilities may need to be established before HOT lane projects can actually be implemented. While an increasing number of state departments of transportation are studying the HOT lane concept as a strategy to improve urban highway service, currently, there are only five operating HOT facilities in the United States.

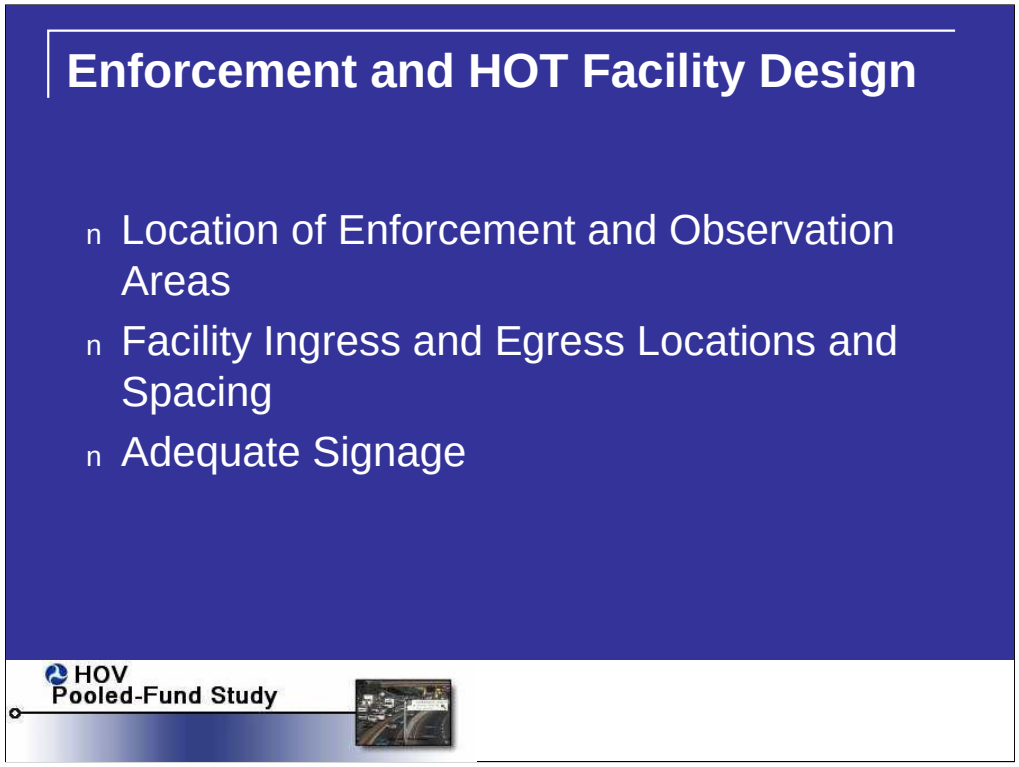


In the context of HOT lanes, the term "operating concept" refers to the process by which vehicles on the HOT facility are differentiated into toll and HOV users. Two types of operating concepts are currently being used on existing HOT facilities:

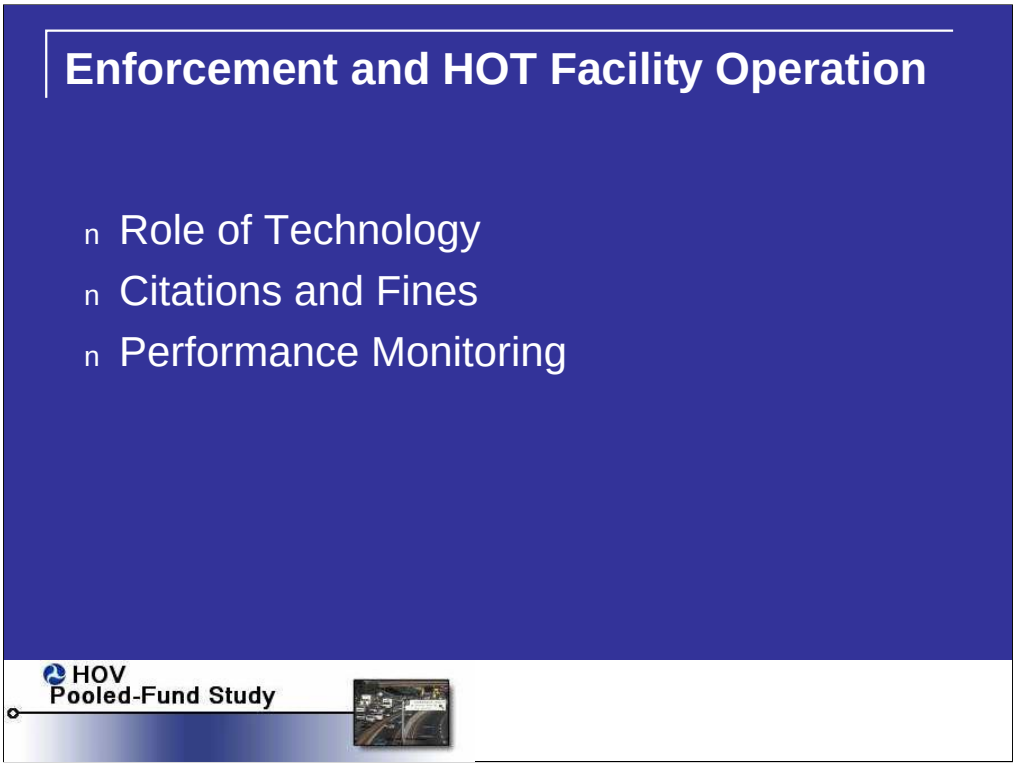
Under an "Ineligibles Tagged" operating concept, vehicles not meeting the eligibility/occupancy requirements for the HOT facility are the only vehicles required to have a toll transponder. At a stationary enforcement zone or through roving patrols the vehicle occupancy is first checked, and for vehicles not meeting occupancy requirements the toll payment must also be verified. Automated violation enforcement systems (VES) have thus far not been implemented under this scenario, since not all vehicles are required to have transponders. Under the "Universal Tag" operating concept, all vehicles in the HOT lane are required to have a toll transponder, including HOVs, and violation enforcement systems (VES) using photographic methods are used to enforce toll payment. Users in vehicles that meet the eligibility/occupancy requirements for the HOT facility (those that get a free or discounted trip) are required to access a special lane to receive a reduced (or zero) toll for the trip. The special lane could be an in-line pullout on the main lanes, or a pullout lane on a ramp or in a connecting park-and-ride facility. At this discount/credit lane the vehicle occupancy is visually verified.



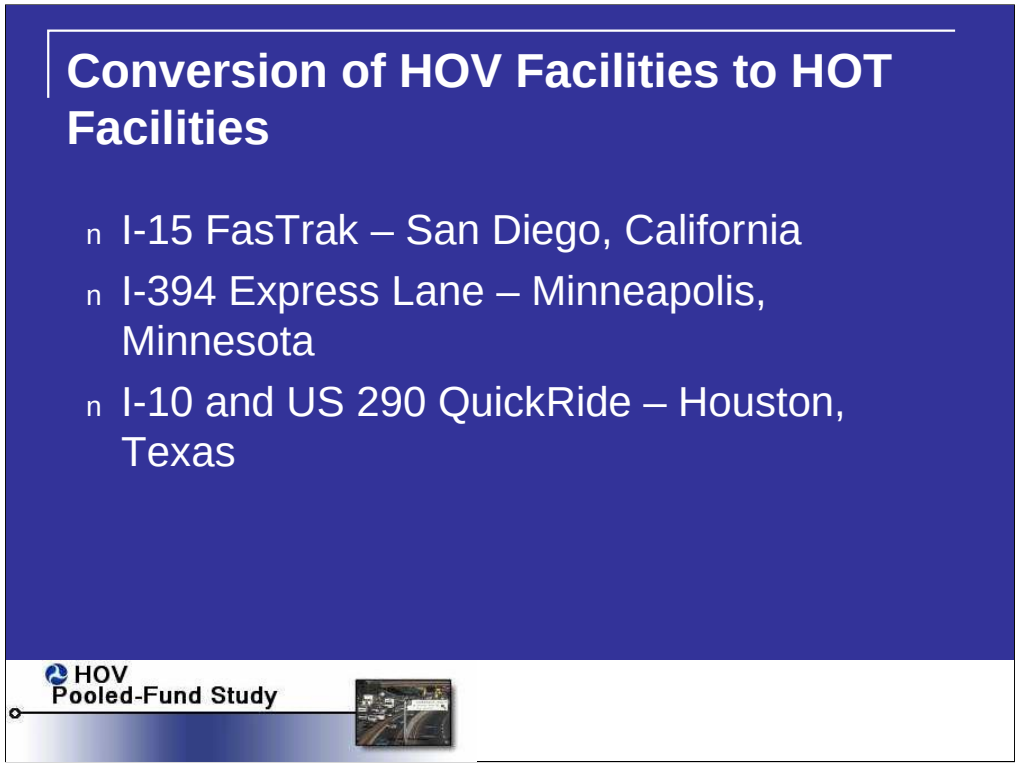
HOT projects require an unprecedented degree of multi-agency cooperation. Ownership and operating structures may vary widely and involve organizations ranging from for-profit private sector developers to toll authorities, local planning organizations, transit agencies, and state departments of transportation (DOTs). The choice between "ineligibles tagged" and "universal tag" operating concepts is perhaps the most critical decision to be addressed in the planning of HOT facilities, as it profoundly influences many aspects of HOT facility design and operations. It is essential that realistic HOT enforcement cost estimates be considered early in the planning process, as adequate HOT enforcement is an expensive proposition. Available information on HOT enforcement budgets indicates costs ranging from $2300 per lane per km up to $5600 per lane per km ($3700 to $9000 per lane/mile). The primary enforcement objective should be to achieve a sufficiently low level of HOT violations. This objective is essential for the long-term success of the facility. Effective enforcement has economic value to the extent that it helps maintain the base of toll users. A related benefit accrues to HOT facility revenue if low-occupancy violators are persuaded by enforcement efforts to become paying toll customers, so that they may travel legitimately on the HOT lanes.



The type of facility, the type of HOT operating concept, and the capabilities of the technologies used to assist enforcement officers all combine to dictate the most effective observation and enforcement locations on HOT facilities. For a barrier-separated facility, it is advantageous to locate some observation and/or enforcement areas slightly downstream of tolling areas on the facility, so that officers can observe transponder status (as shown by a roadside indicator beacon) as well as vehicle occupancy in the tolling zone. In contrast, there are no optimal stationary locations for toll enforcement on concurrent flow facilities. The toll aspect of HOT lanes favors more limited access locations. As with HOV lanes, this can be accomplished by using a painted stripe or buffer zone, or a physical barrier. Physical barriers are preferred for permanent HOT lane installations as they provide better access control and are more effective at reducing violations and maintaining premium traffic service. Accurate, informative signs explaining the operational procedures of HOT lane facilities, such as toll information, are important for safety and enforcement. Informed drivers are less likely to commit unsafe last-minute maneuvers or inadvertently violate the HOT lane. Signage for HOT lanes should generally adhere to the standards prescribed for HOV facilities in the Federal *Manual on Uniform Traffic Control Devices* (MUTCD).



Enforcement personnel must deal with two major types of violations on HOT facilities – those involving a violation of minimum occupancy requirements, and the related problem of toll evasion. Given the limitations of automated technologies and the difficulties of verifying the number of occupants in a vehicle, the enforcement of occupancy requirements mandates routine visual inspection. Toll evasion presents a complementary problem for enforcement personnel, in that visual inspection cannot conclusively verify toll payment, but the problem is readily amenable to technological countermeasures. Violations on most HOT facilities are handled under existing laws regulating HOV lane usage, rather than being classified as toll evasion. Penalties for violations must be adequate to discourage the willful violator such that reliance on dedicated enforcement officers can be minimized. Currently, aggregate penalties on HOT/HOV projects in the United States vary from $45 to $351 for a first offense. While the information gathered by a monitoring program may not differ substantially from that discussed for HOV facilities, the importance of performance monitoring to continuing enforcement operations can arguably be seen as greater in the context of HOT facilities. Here, each violation has a direct economic impact on the HOT facility in the form of lost revenue from toll evasion. Additionally, performance monitoring has acquired critical importance with recent changes to federal law.

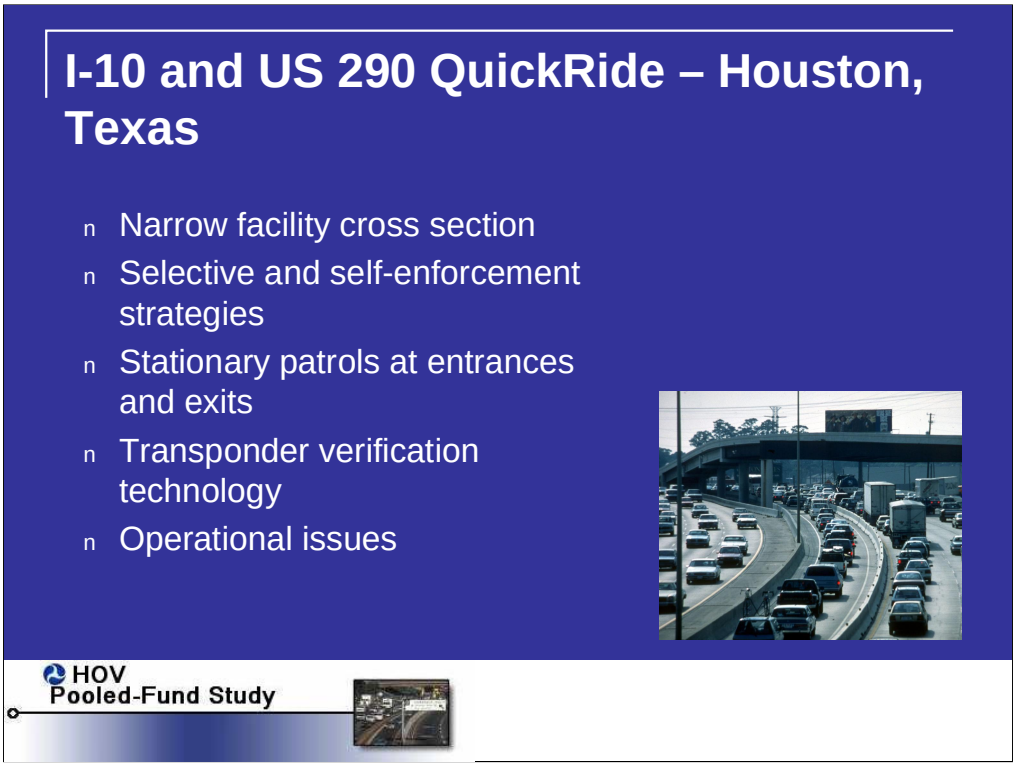


General recommendations addressing conversion issues for HOV facilities are practically synonymous with those from the preceding discussions in this chapter, as nearly all HOT facilities in existence are conversions. The next few slides examine the three HOT conversion projects shown here, highlighting the individual enforcement features and enforcement-related implementation issues encountered.

The I-15 Express Lanes are a 13 km (8 mile) two-lane, barrier-separated reversible HOV facility in the median of Interstate 15. Access to the Express Lanes facility is available only at its north and south ends during morning and evening peak traffic periods. The I-15 Express Lanes employ variable pricing based on time of day. Full left and right shoulders are provided along the length of the facility. Selective enforcement is provided by CHP under a $60,000 yearly contract. This supports 12 four-hour shifts per month, one officer per shift. Stationary patrols, with an officer located in the tolling zone, are used as well as roving patrols. CHP uses motorcycles or police cruisers, although motorcycles are preferred. The officer visually inspects vehicles for occupancy while observing a beacon controlled by the toll reader. SOVs with a valid toll transponder will illuminate the green beacon otherwise an HOV violation has occurred. Manual counts for occupancy and occupancy violations are performed on a quarterly basis. Violation rates are approximately 5 percent.

For the first two years of HOT operation, the tolling zone had an extra lane for SOVs to aid occupancy enforcement. SOV users complained about the amount of weaving required to merge in and out of the extra lane; that and potential safety concerns led to the elimination of the SOV lane. Video monitoring was attempted in the initial stages of the project for occupancy detection, but was abandoned in 1998. Operators using the system could not reliably distinguish SOV violators on the videotapes, and found it difficult to discern the number of vehicle occupants, especially for those in back seats.

This newly implemented facility combines a segment of two-lane, barrier-separated reversible HOV lanes with another section of limited-access concurrent flow lanes. The median shoulder on the concurrent flow segment is narrow, while somewhat wider shoulders are located along the barrier-separated segment. Stationary patrols can be used at the beginning and end of the barrier-separated segment, as sufficient shoulder space is available there; otherwise enforcement is restricted to roving patrols. Selective enforcement is used, with a $200,000 startup budget supporting 12 four-hour peak periods per week. Roving patrols use special enforcement transponders to verify toll payment by SOVs. Enforcement beacons are mounted on overpasses situated near a tolling zone, and will flash if a vehicle passing through the zone has a valid transponder placed properly in the vehicle. Mobile transponder readers are devices installed in enforcement vehicles that allow an officer to either park anywhere on the shoulder of the road and read the transponders of passing vehicles or to travel adjacent to a vehicle in the HOT lanes and read the transponder. Comments by enforcement personnel indicate that the enforcement transponders and enforcement beacons are not as effective as had been hoped. The mobile enforcement reader is favored by officers, as it can provide them with positive confirmation of toll transactions. An upgrade to this system is being planned which will give officers the ability to monitor transponders on either side of the enforcement vehicle. This feature is necessary in the two-lane reversible section of the facility, where currently officers can only read transponders if they are traveling in the right lane.



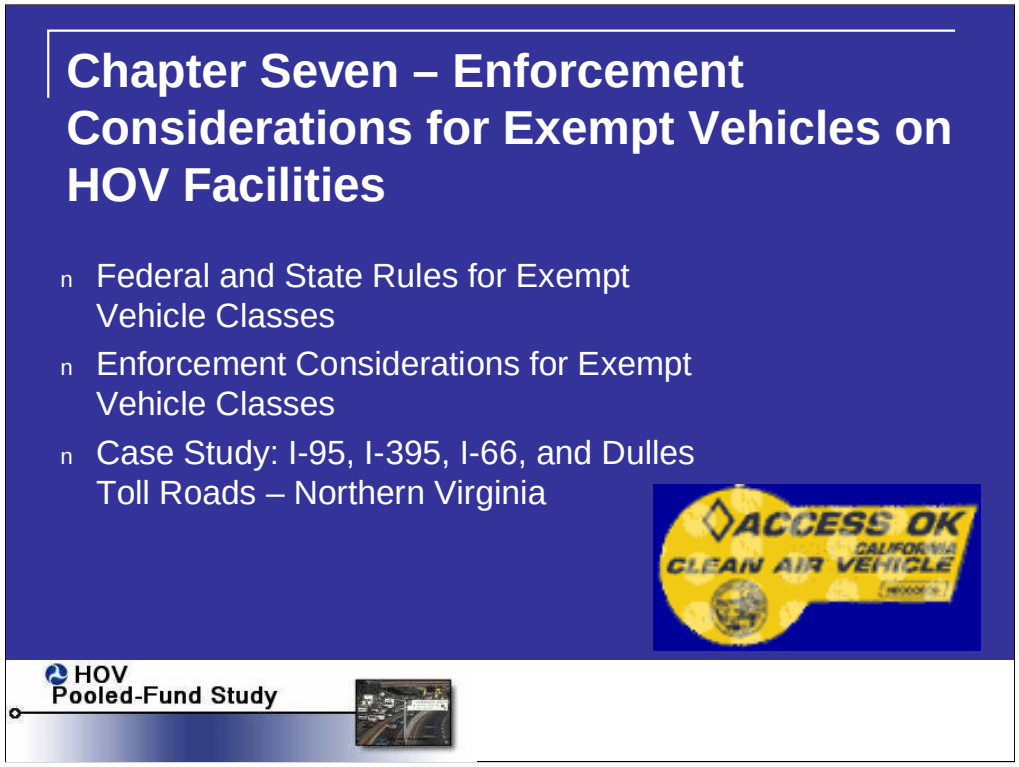
These facilities are both one-lane, reversible, barrier-separated HOT lanes in the medians of the I-10 and US 290 freeways in Houston, Texas. Limited right of way resulted in a narrow facility cross sections, so that enforcement is only possible at entrances and exits to the facilities. Selective enforcement is used, averaging one to two peak periods per week with one officer, and occasional task forces involving multiple officers. A HERO program of self-enforcement has also been operational in the Houston area for over 10 years. The program consists of a dedicated phone number that is available for motorists to call and report a violator on any of the HOV lanes. Stationary patrols are used at entrances and exits, primarily near the inbound termini to the facilities. Four HOT access ramps along US 290 are each equipped with a stand-alone roadside AVI system, which is designed to monitor HOV traffic and indicate the presence of a valid QuickRide transponder in passing vehicles. In addition, PDA-based handheld AVI readers provide apprehending officers with the ability to scan transponders for validity and proper functioning. Data on violation rates observed in 2003 found violation rates to be excessively high – between 55% and 65% of the users on the HOV lanes were not in compliance with either minimum vehicle occupancy or QuickRide program requirements during peak periods. A recently completed FHWA study demonstrated that violation rates can be significantly reduced by both increasing law enforcement coverage and employing technology to assist officers in verifying QuickRide accounts.

Case Study: SR 91 Express Lanes, Orange County

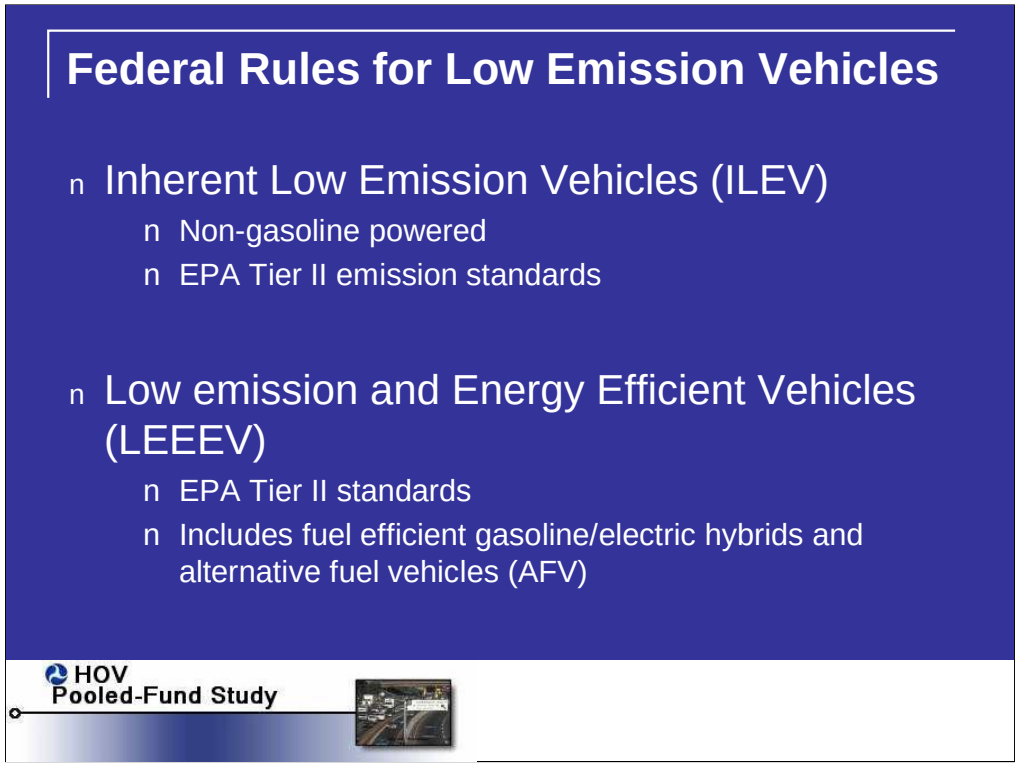
- Periodic enforcement areas
- Special enforcement
- Stationary, roving, and team patrols
- Universal tag operating concept
- Automated toll enforcement

HOV Pooled-Fund Study

The SR 91 Express Lanes are a HOT facility in the median of an existing highway. The section of California State Route 91 (SR-91) containing the express lanes is located between the SR-91/SR-55 junction in Anaheim and the Orange/Riverside County Line. The project provides two extra lanes in each direction, separated from the adjacent freeway by a "soft" barrier consisting of a double-yellow stripe painted buffer with pylons. The Express Lanes have only minimal median shoulders along most of their length. Bi-directional enforcement areas with offset median barriers are provided at periodic intervals along the facility. Special enforcement is provided by CHP, with yearly contract enforcement cost of approximately $360,000. This enables 24 hour enforcement of the facility. All traffic using the facility are required to have toll transponders. HOV3+ vehicle occupancy is verified by a spotter adjacent to a dedicated carpool-only lane within the tolling zone, and descriptions of suspected violators are radioed to California Highway Patrol officers downstream. Non-carpool traffic toll violations are handled automatically by video and license plate recognition. Repeat toll violators who remain delinquent in paying tolls and penalties are tracked by the operating agency. Violation rates are under 2 percent.



Chapter Seven discusses enforcement considerations pertaining to some of the exempt vehicle classes permitted on HOV facilities, particularly the class of low emission vehicles and of law enforcement and emergency services vehicles. A survey of regulatory and legislative treatments for these vehicles is presented, with current guidance and recommendations from recent study efforts also included.



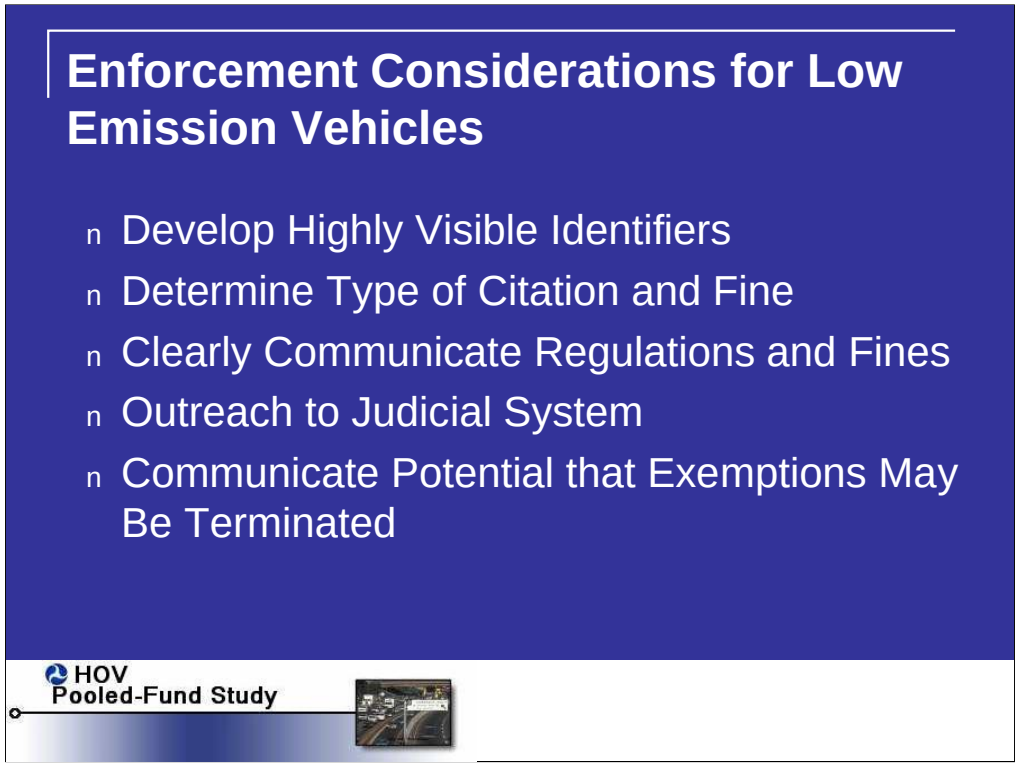
Federal legislation allows states to authorize HOV occupancy exemptions for two types of low emission vehicles. Inherently Low-Emission Vehicles must use a dedicated non-gasoline clean fuel, such as compressed natural gas, liquid natural gas, hydrogen, ethane, methane, or liquified petroleum gas. Low-emission and Energy-Efficient Vehicles include gas/electric hybrids meeting EPA Tier II emission standards and which achieve a 50 percent increase in city fuel economy or not less than a 25 percent increase in combined city-highway fuel economy relative to a comparable vehicle that is an internal combustion gasoline fueled vehicle. Alternative Fuel Vehicles (AFV) meeting EPA Tier II emission standards also qualify.

State Rules for Low Emission Vehicles

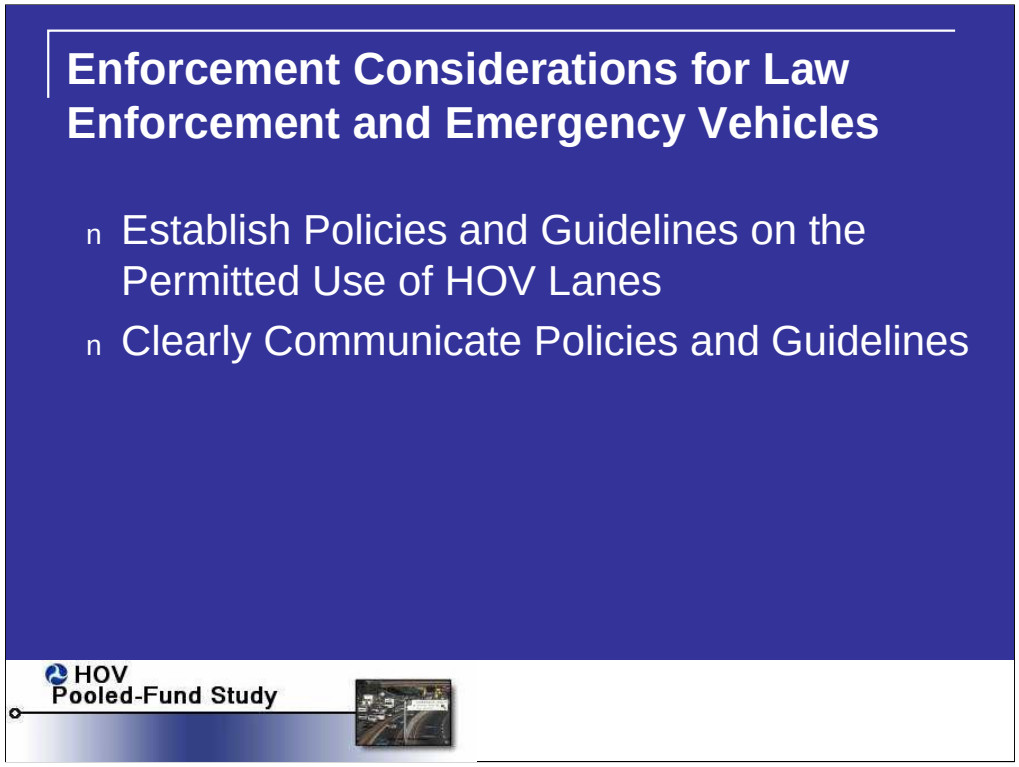
State	Vehicles Exempted		Identification Requirement	Type of Violation	Fines
	Non Gasoline	Hybrid Gas/Electric			
Arizona	ü	O	Stickers / Decals	Misuse of Plates	$350
California	ü	ü	Stickers / Decals	Unauthorized Use	$351 to $ 876
Colorado	ü	O	Stickers / Decals	Unidentified ILEV	$65 to $125
Florida	ü	O	Stickers / Decals	Unauthorized Use	$78
Georgia	ü	O	License Plate	Unauthorized Use	$101 to $176
Utah	ü	O	License Plate	Unauthorized Use	$138
Virginia	ü	ü	License Plate	Unauthorized Use	$89 to $1039

HOV Pooled-Fund Study

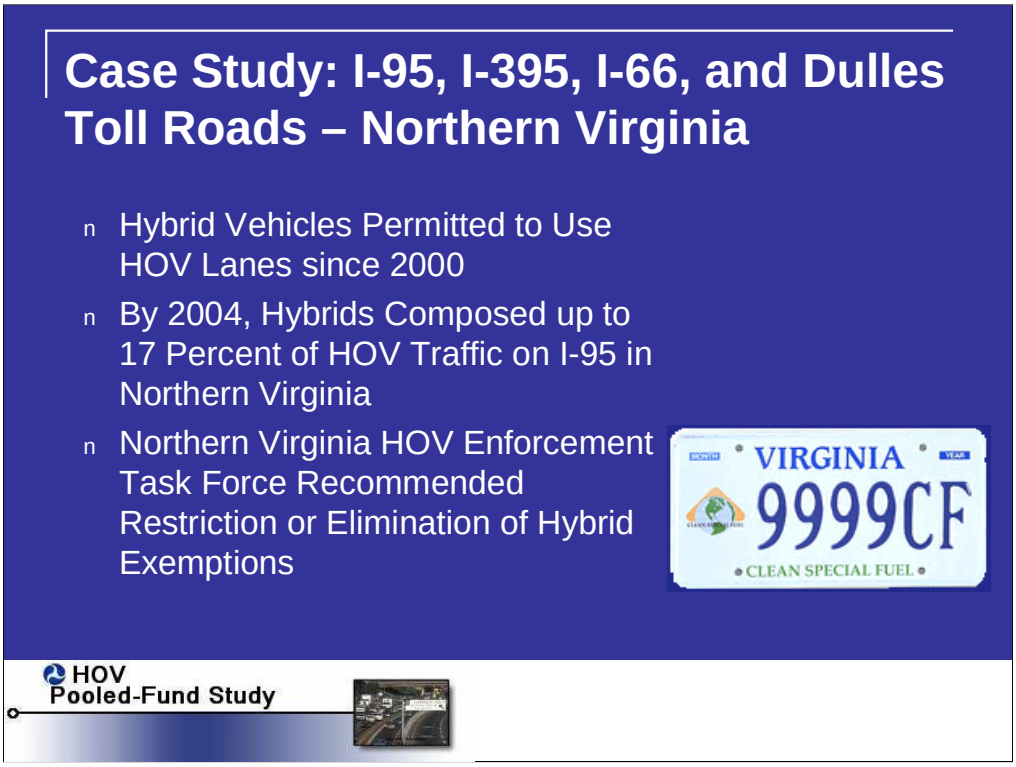
Seven states permit exemptions for low emission vehicles on HOV Lanes. Only Virginia and California allow exemptions for gasoline/electric hybrids. The rest of these states restrict the exemption to non-gasoline alternative fuel vehicles. With the recent clarification of federal rules regarding hybrid vehicles, more states may offer HOV exemptions for hybrid vehicles in coming years. Low emission vehicles must be identified either by stickers, decals, or special license plates. Only Arizona and Colorado have specific laws for HOV violations related to low emission vehicles. Arizona penalizes violators who improperly use special Alternative Fuel Vehicle plates, while Colorado cites owners of low emission vehicles who use the HOV lanes without the required decals. The rest of these states use general laws against unauthorized use of the HOV lanes to handle these types of violations.



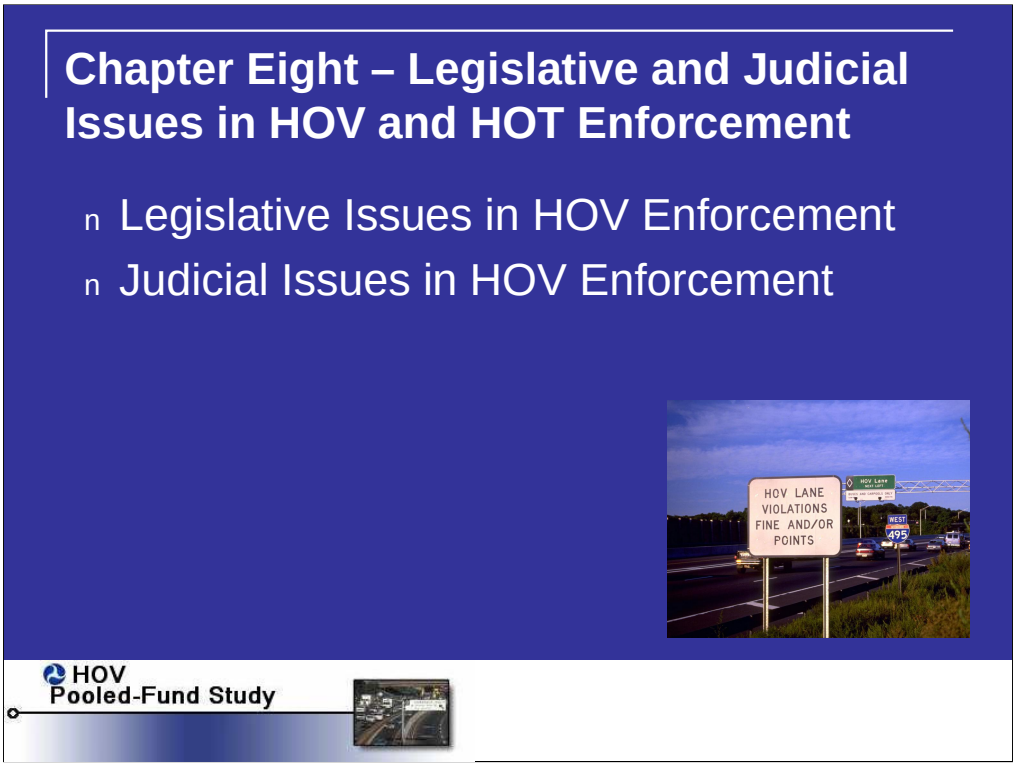
Low emission vehicles are required to display identifiers. Special stickers or decals should be large enough to permit identification at a distance, and should be located on areas of the vehicle that can be readily seen by an observing officer. Special license plates for low emission vehicles should incorporate distinctive elements such as graphic insignia and a designated prefix or suffix in the plate number. Lawmakers should consider whether violations of the regulations for low emission vehicles on HOV facilities should be treated differently from violations of HOV occupancy restrictions. The regulations for use of the HOV facilities by low emission vehicles and the penalties for violating these regulations should be clearly communicated to commuters and travelers in the corridors and the general public. Extra outreach may be needed with judges and other groups to explain the exemption regulations and the fines and citations associated with violating the regulations. Numerous methods are available for communicating the possibility that access to HOV lanes by environmentally friendly vehicles or other exempt vehicles may be terminated in the future or in real-time as operating conditions warrant. Potential communication methods should be targeted to the public at large, to travelers in corridors with HOV lanes, and to owners of the exempt vehicles.



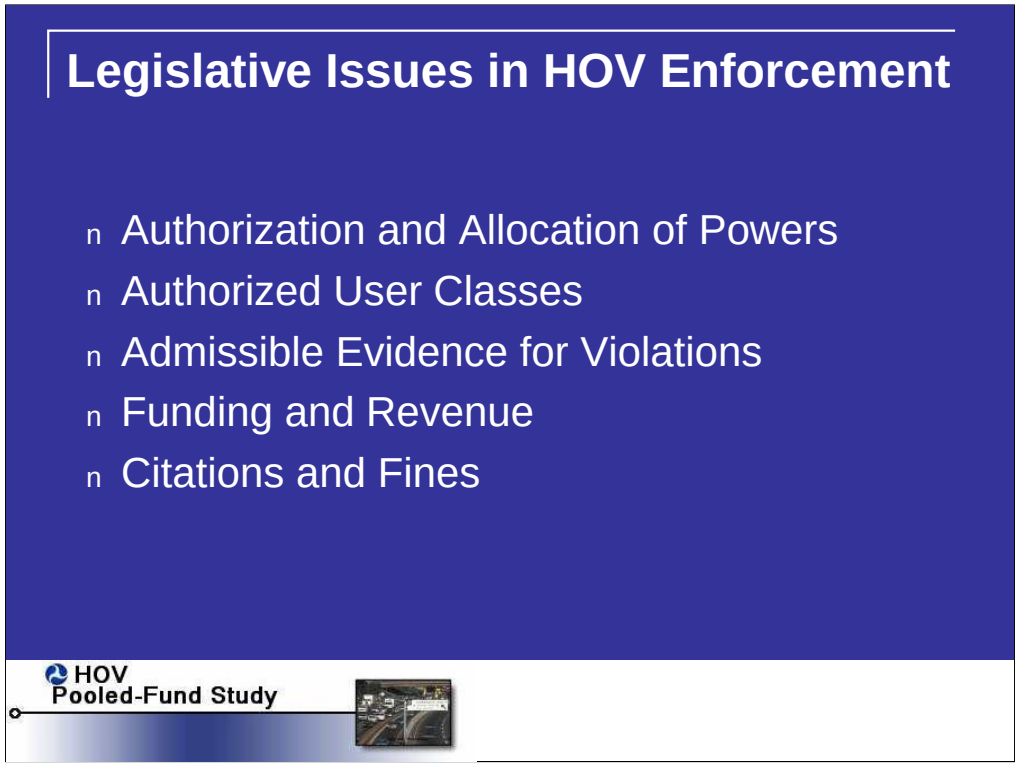
Generally, HOV lane use by law enforcement and emergency vehicles that are clearly marked and equipped with rooftop emergency lights and a siren is relatively low. However, law enforcement and emergency personnel traveling alone in their personal vehicles or in an unmarked agency vehicle when not on duty may be an issue in some areas of the country. It is important to ensure that current policies and guidelines clearly articulate the types of law enforcement and emergency vehicles that can use an HOV lane without meeting the occupancy requirements. The policies and guidelines should be clearly communicated to the agencies responsible for law enforcement and emergency services, policy makers, and the public.



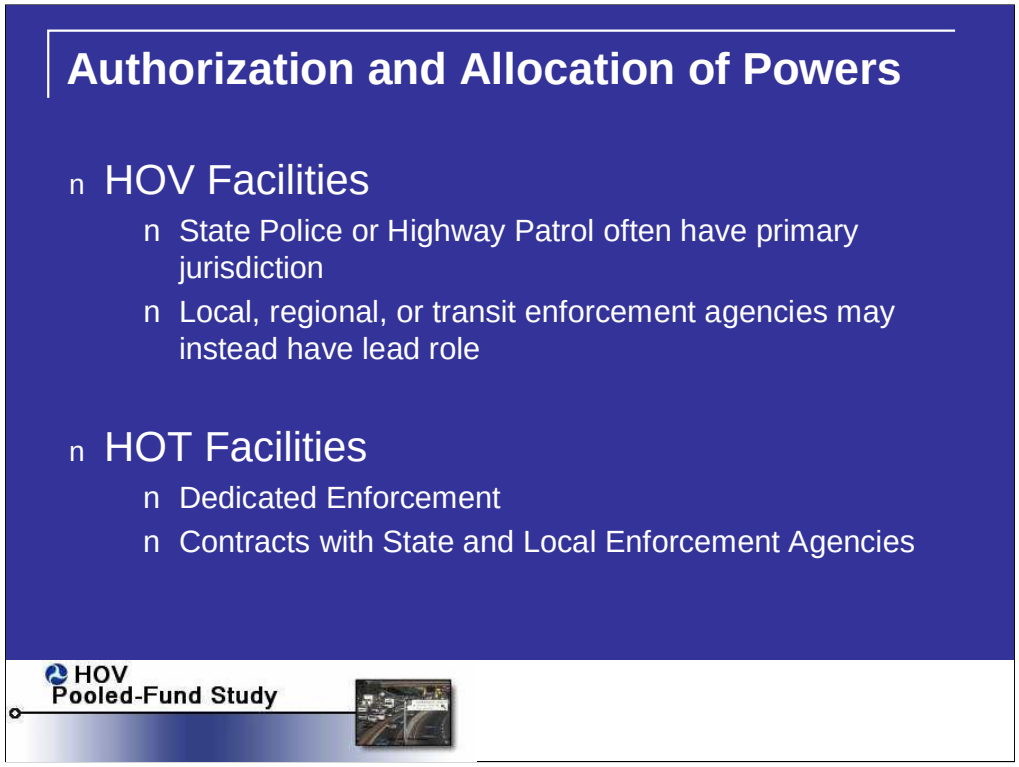
The I-95, I-395, I-66, and Dulles Toll Road HOV lanes serving Northern Virginia present a particularly relevant example of the enforcement issues associated with exempt vehicles. The number of hybrid vehicles using HOV lanes in Northern Virginia has grown dramatically following a decision to waive the HOV minimum occupancy restriction for these vehicles. Despite the fact that on a statewide basis Virginia still has excess capacity on its HOV system, the HOV lanes in northern Virginia are facing congestion resulting from the hybrid exemption. An HOV Enforcement Task Force convened in 2003 to find and recommend solutions to improve enforcement. In its 2003 and 2005 reports, the Task Force recommended that the number of clean special fuel plate vehicles should be restricted. It suggested measures such as more stringent emission requirements, increasing the required number of vehicle occupants, increasing the issuance fee for clean special fuel plates, and limiting the hours that low emission vehicles can use the HOV facilities. The task force also found that policies regarding usage of the HOV lanes by law enforcement and emergency personnel must be clarified.



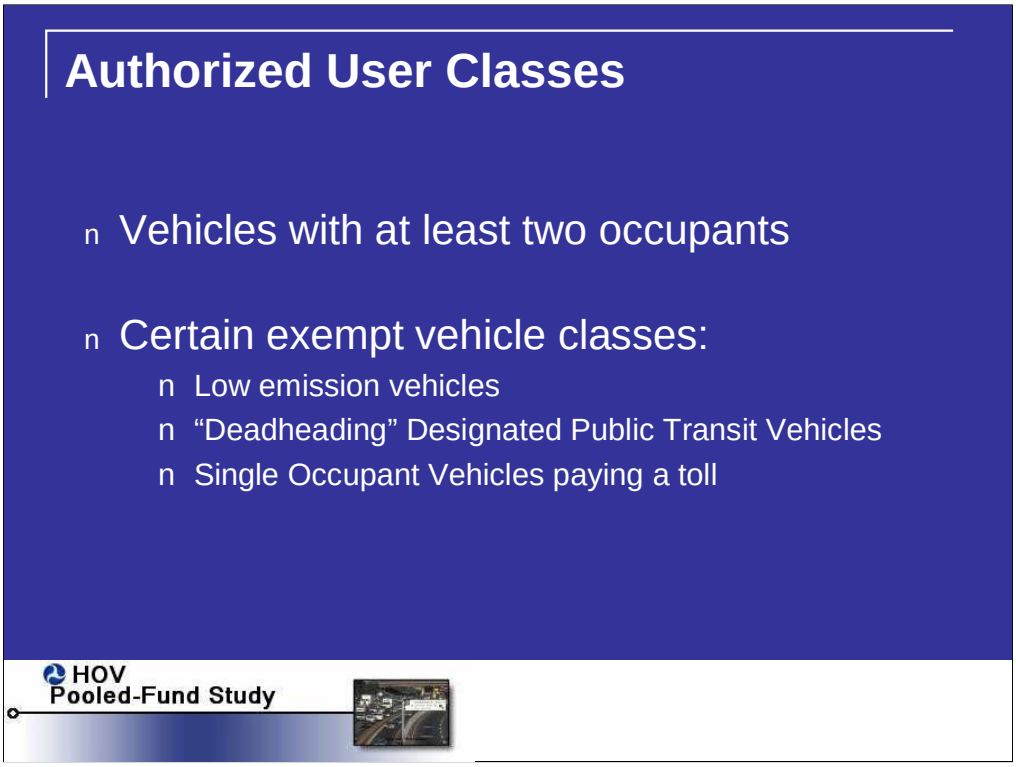
Chapter Eight describes the relevant legislative and judicial issues affecting enforcement along HOV and HOT facilities. Pertinent examples of federal, state and local legislation are included, and salient issues related to the adjudication of HOV violations are discussed.



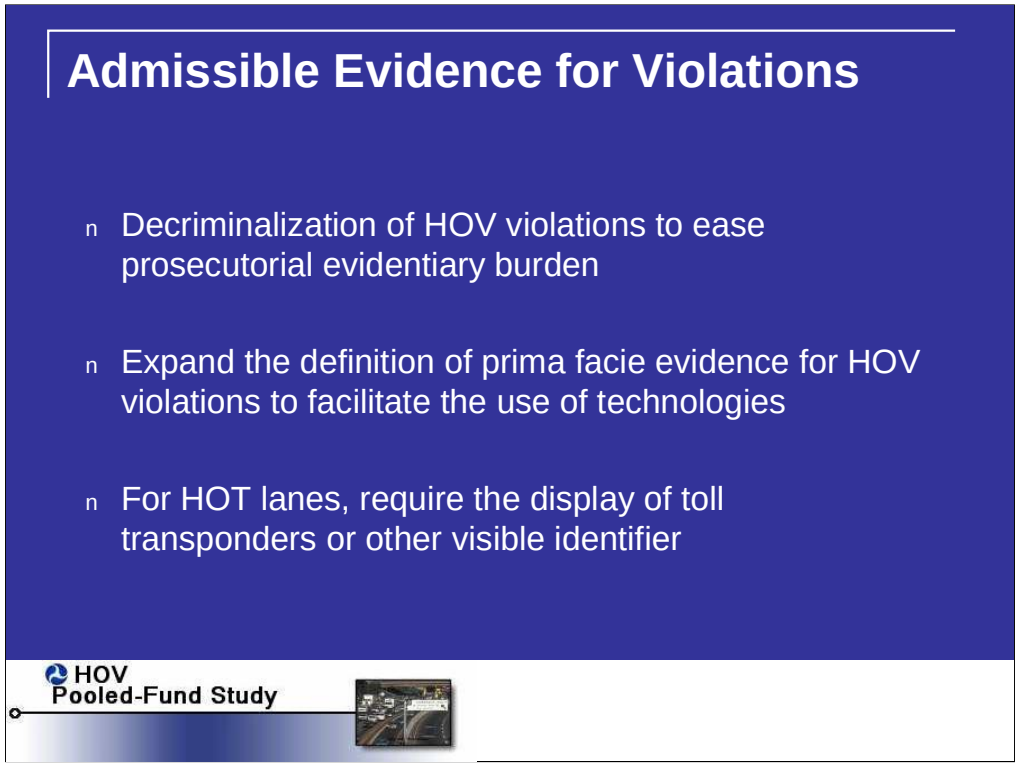
As rulemaking bodies, legislatures have, within their respective scopes, considerable influence in many areas of HOV and HOT enforcement. The principal areas of legislation most pertinent to enforcement include the authority and jurisdiction of enforcement agencies, vehicle eligibility on HOV/HOT facilities, standards of evidence for violations, provisions for funding of enforcement operations, and the nature and severity of penalties for HOV/HOT violations.



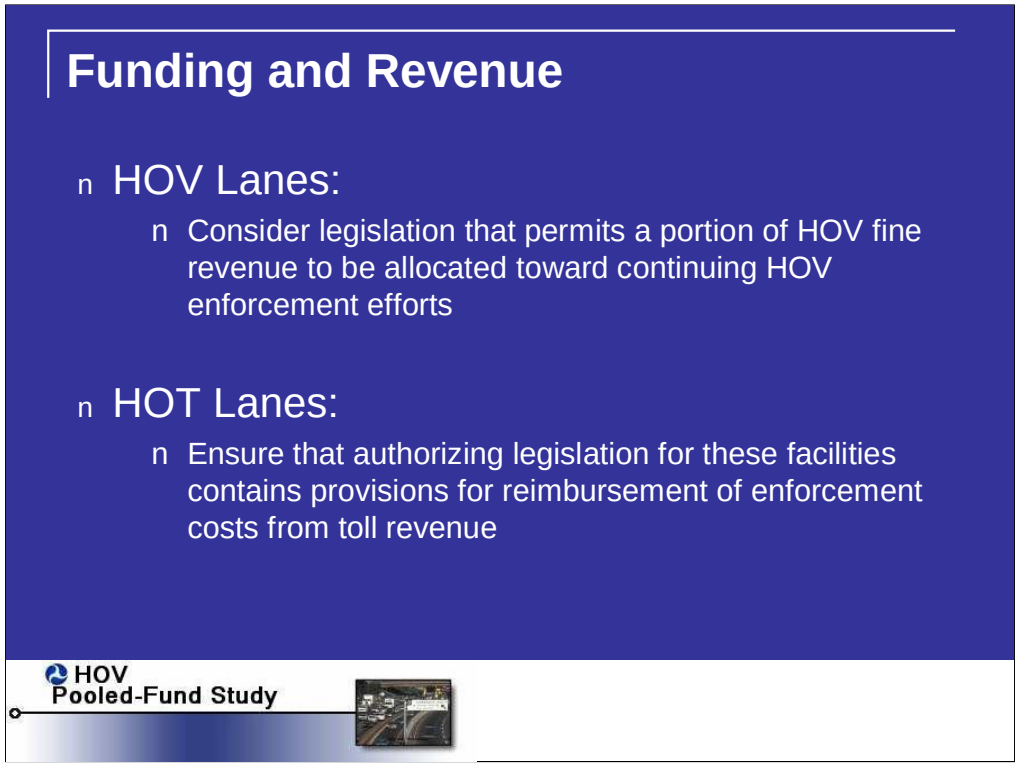
The agency responsible for enforcing the operating requirements of an HOV facility must have the legal authority to do so. This authority must include the ability to issue citations to individuals violating vehicle eligibility regulations, vehicle occupancy requirements, hours of operation, speed limits, and other operating regulations. The authorization and allocation of powers for enforcement of freeway HOV facilities is handled through a combination of state regulations and local ordinances, so long as those laws do not conflict with any federal regulations governing the operation of federal-aid highways. Most commonly, such legislation designates primary responsibility for HOV enforcement to the state patrol or state police. Some states may instead assign primary HOV enforcement responsibilities to local or regional agencies. Other agencies with the power to enforce HOV requirements may include transit authorities. HOT facilities generally require some form of dedicated enforcement, which can often be financed through toll revenue. In addition, HOT facilities may also be operated by private entities. Most state legislation authorizing HOT facilities includes provisions by which the facility operator can enter into contractual arrangements with various state or local enforcement agencies.



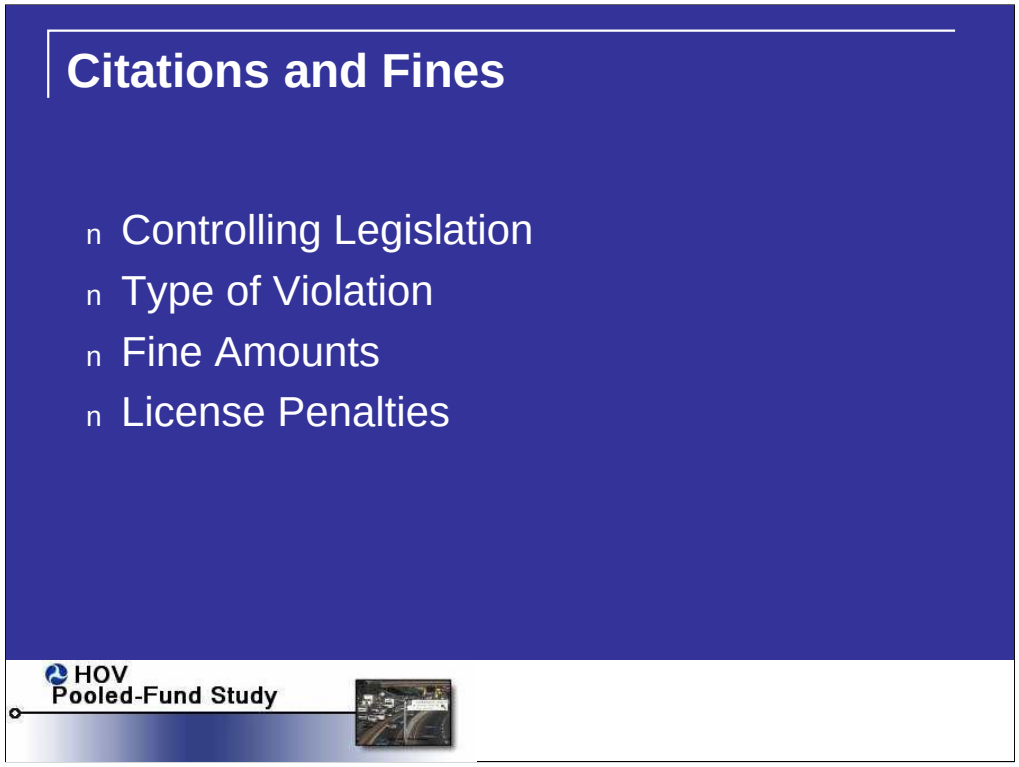
Operating agencies are required to restrict the use of the HOV lanes to vehicles with at least two occupants. Motorcycles are also permitted, subject to safety restrictions which may be imposed by the operating agency. Federal rules also allow operating agencies to designate exceptions to the minimum occupancy rules for certain classes of vehicles, such as Low Emission and Energy Efficient Vehicles, "deadheading" designated public transit vehicles, and single occupant vehicles paying a toll.



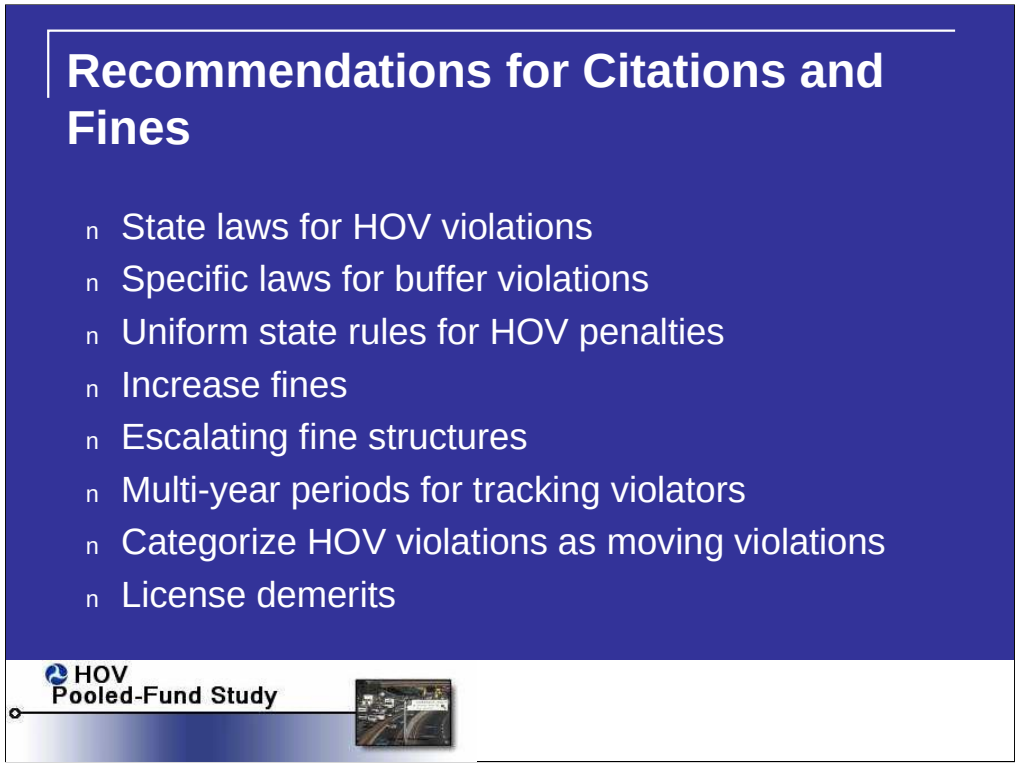
Many, if not all states use civil administrative procedures to deal with HOV violations, and some states have additionally passed legislation pertaining to prima facie evidence of HOV violations as a means of enabling "ticket by mail" enforcement programs. While decriminalization and legislation pertaining to prima facie evidence of vehicle occupancy violations have facilitated adjudication, they have thus far proved inadequate to permit further streamlining of the HOV enforcement process by techniques such as ticket by mail and automatic photo/video enforcement. The following recommendations are made after a review of state laws.



Funding for continuing enforcement efforts on HOV facilities is limited to that which is available through normal or special legislative appropriations and interagency agreements, although the level of funding from these sources may sometimes be substantial. Well-financed enforcement programs such as these are often exceptions, however, and many HOV facilities must make do with budgets that support little more than routine enforcement. Independent continuing sources of revenue, such as the revenue from the collection of HOV fines, are typically not directly available to enforcement agencies, although there has been a recent state legislative effort to make this source available. HOT lanes, unlike HOV lanes, do benefit from state legislation that permits the financing of enforcement efforts through toll revenue generated by these facilities.

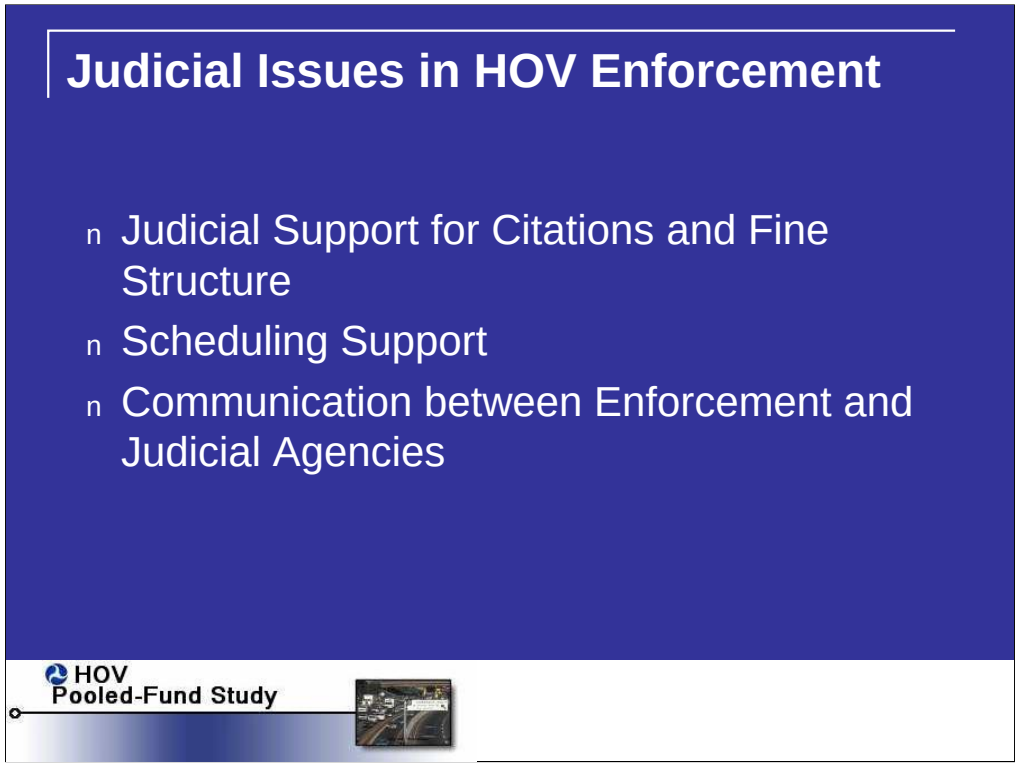


Legislation governing the citation and fine structure for HOV violations incorporate several characteristics, each of which influences the potential effectiveness of enforcement and violator behavior. Laws for HOV violations can be enacted on the state or local level. Alternatively, existing state or local laws can be used to enforce HOV regulations. However, laws explicitly addressing HOV violations at the state level have a greater chance of being uniformly applied. On buffer-separated or non-separated HOV facilities, enforcement personnel must concern themselves with an additional type of HOV violation. Motorists who violate the buffer or double lines indicating prohibited access to the HOV lane pose a serious safety hazard to traffic in the HOV and general-purpose lanes. Fines constitute the chief deterrent against HOV violators. Fine assessments for HOV violations vary widely among the various states, and the general experience with fines for non-compliance with HOV facility operating requirements is that higher fines equate to lower violations. Next to the potential cost of a ticket, the possible imposition of demerits on a driving record provides the greatest deterrent to potential HOV violators. Demerits or "points" provide an additional weapon with which to combat persistent, repeat violators, as the higher insurance premiums and the possible loss of driving privileges resulting from multiple point assessments can impose substantial costs and inconvenience.

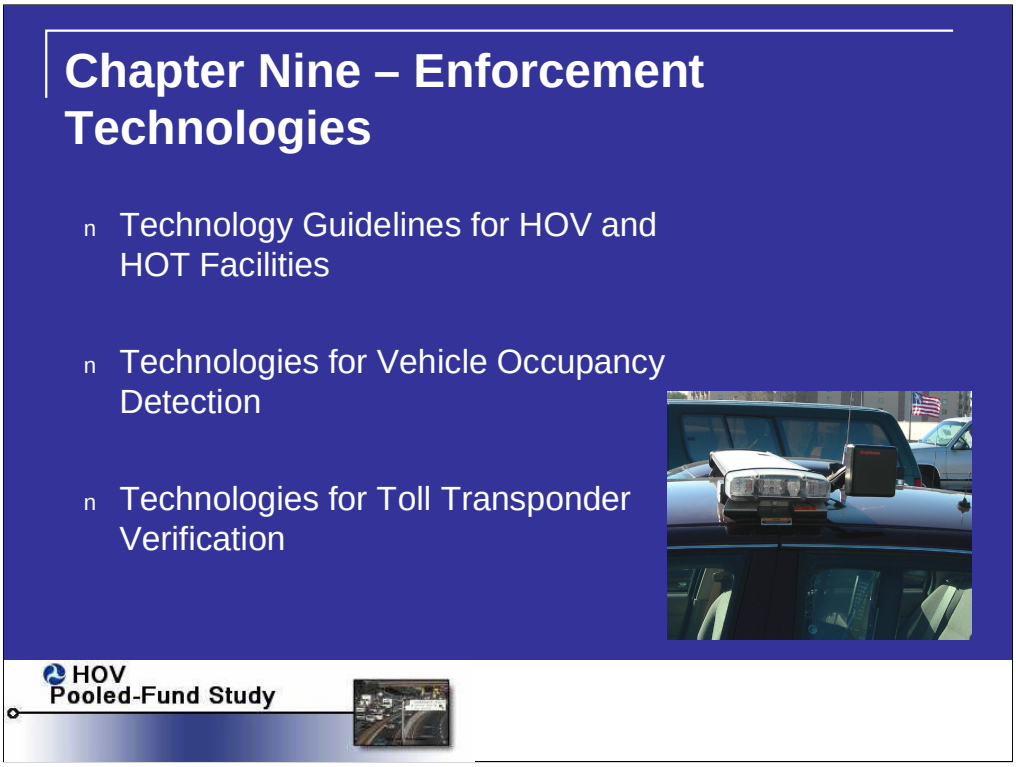


The following guidance is offered for HOV citations and fines after a review of state laws:

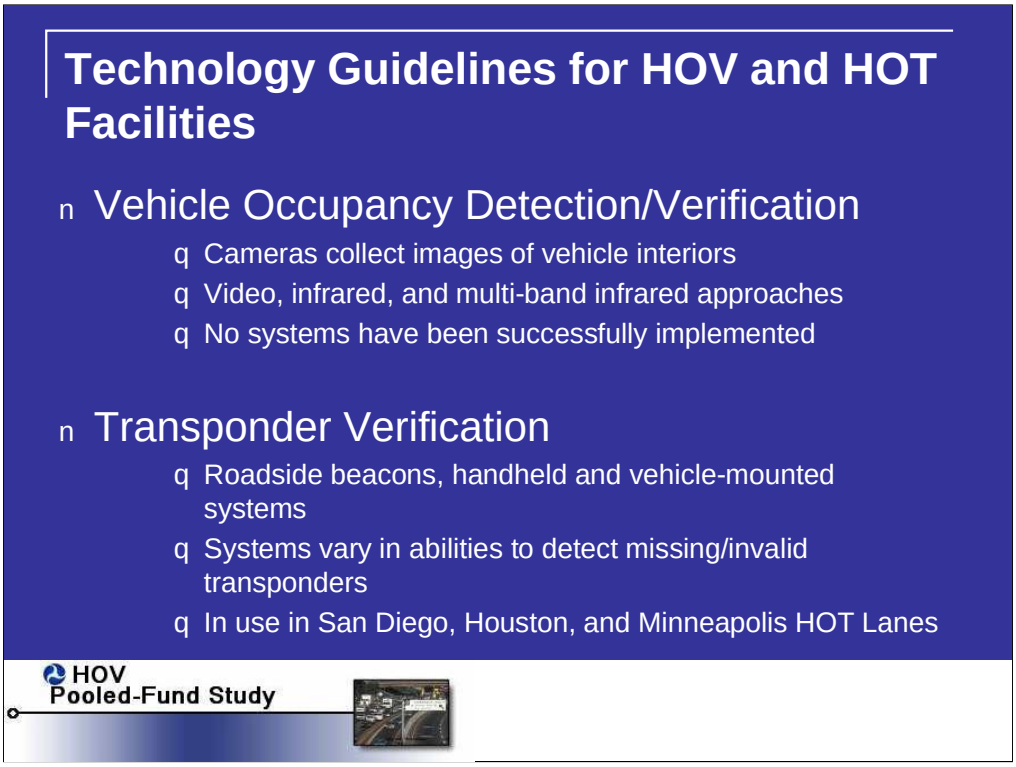
- Consider enacting state laws which explicitly categorize HOV violations, so as to facilitate consistent enforcement and adjudication.
- Consider enacting specific laws for buffer violations on HOV facilities
- Enact uniform state rules for HOV penalties to reduce inconsistent judicial fine assessments, and to facilitate public awareness of fine amounts.
- Set fine amounts to a level which constitute a credible deterrent to potential violators.
- Enact escalating fine structures with substantial penalties for repeat offenders.
- Consider multi-year periods for the tracking of repeat offenders to maximize effectiveness of an escalating fine structure.
- Consider changes to motor vehicle codes which would categorize HOV violations as moving violations.
- Consider implementing demerit points for HOV violations to deter repeat violators.



A good enforcement program can be undermined by the judicial branch of government if the judicial branch does not uphold the citations issued by the enforcement agency. In addition to possible judicial unfamiliarity with HOV laws, the time spent by officers supplying witness testimony against defendants poses another difficulty for enforcement. These extra hours can increase the expense of enforcement as well as divert manpower, and it is in the best interest for enforcement and judicial agencies to closely coordinate the scheduling of testimony to minimize any possible delays that officers may experience while performing this activity. It is important that judges develop an appreciation for the objectives of the HOV project and the enforcement approach needed to achieve the objectives. Briefings for traffic court judges regarding a HOV facility and its associated traffic regulations can be an important consideration influencing court attitudes. Judicial appreciation of the merits of the HOV facility helps toward developing the proper judicial support for the project.



Chapter Nine reviews existing and newly emerging technologies applicable to HOV enforcement, beginning with a discussion of the different requirements posed by HOV facilities and High Occupancy Toll (HOT) facilities, and continuing on to discuss technologies available for HOV and HOT enforcement.



Most attempts at developing enforcement technologies specifically for HOV facilities have focused on vehicle occupancy detection and eligibility verification. A vehicle occupancy detection system utilizes one or more cameras and illumination sources to collect images from the interior of passing vehicles. Technologies for occupancy detection systems have been developed and tested over nearly two decades. Systems range in complexity from operator-monitored video cameras though automated processing of infrared composite images. To date, none of these systems are in regular use, as they have either proved themselves inadequate for the task, or have yet to progress past the point of limited field tests. Transponder verification refers here to any technologies or methods by which enforcement personnel can receive real-time information on the status of in-vehicle AVI transponders. Existing technology is available for addressing the problem of toll verification on HOT facilities. Solutions commonly involve communicating AVI toll or transponder information to enforcement personnel, allowing them to more fully concentrate on counting vehicle occupants.

Technologies for Vehicle Occupancy Detection

Technology	Benefits	Drawbacks
Video	Commercially available systems Relatively inexpensive	Poor resolution Inferior to visual inspection Cannot operate autonomously Unusable in low lighting
Infrared	Usable under all lighting conditions	Not developed past custom prototypes Cannot penetrate metallic window tint Cannot operate autonomously Cannot distinguish human skin from other objects of similar temperature Expensive
Multi-Band Infrared	Can distinguish unique infrared signature of human skin Usable under all lighting conditions Can potentially operate autonomously	Not developed past custom prototypes Cannot penetrate metallic window tint Extremely expensive

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Video Systems have been deployed in the past for vehicle occupancy detection. While video continues to serve a useful role in HOV facility monitoring, it has not proven adequate for the task of vehicle occupancy verification. The collective experience from several studies and implementation projects has concluded that video methods are not as reliable as live visual inspection. No occupancy detection systems based on infrared imaging have ever been implemented on HOV facilities, although a few recent field tests have been conducted. The primary potential benefit offered by infrared systems is the ability to operate in darkness as well as daylight. Infrared systems otherwise suffer from many of the same shortcomings as conventional video, especially with respect to heat-blocking or metallic vehicle window tint. Infrared systems are also substantially more expensive than conventional video systems.

Technologies for Toll Transponder Verification

Transponder Verification Device	Detection Capabilities	Drawbacks	Facilities Implemented
Roadside Indicator Beacon	Valid transponder	Limited siting options Line of sight enforcement Difficulty matching vehicles to indicator status Cannot verify malfunctioning transponder	I-15, San Diego I-394, Minneapolis US 290, Houston
Handheld Reader	Valid transponder Malfunctioning transponder	Very limited range Useful only after apprehension Cannot verify toll payment	US 290, Houston
Vehicle-mounted Reader	Valid transponder Malfunctioning transponder Can verify toll payment	May require dedicated enforcement vehicle	I-394, Minneapolis

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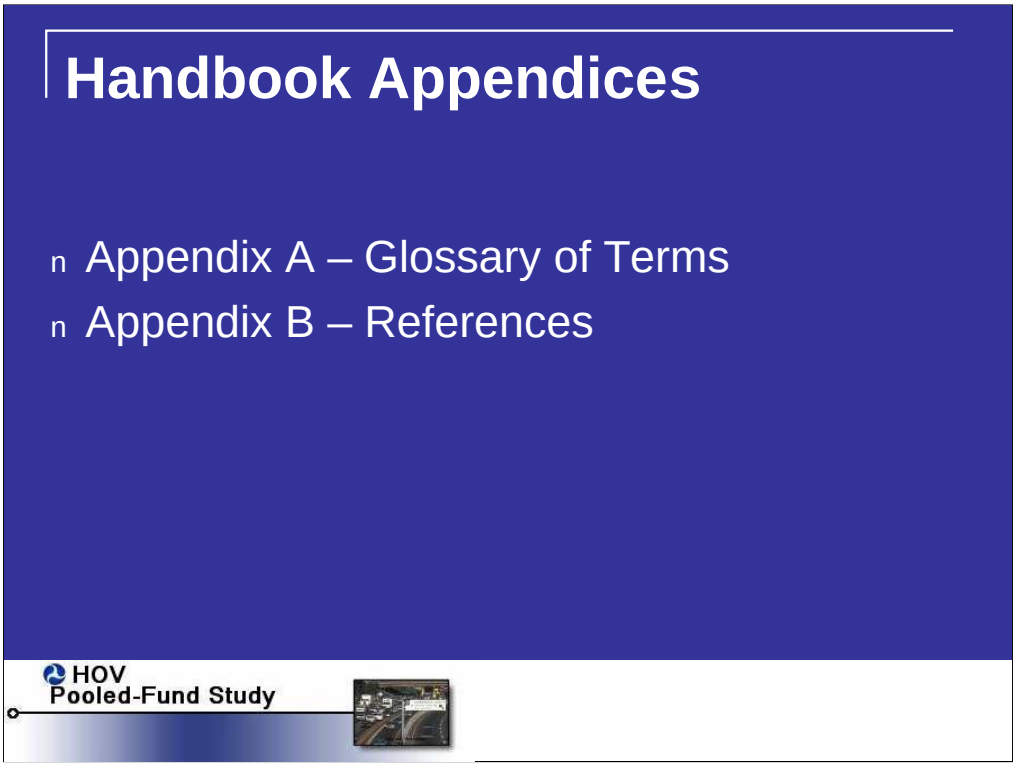
One approach to transponder verification uses an AVI-activated overhead beacon mounted on the toll reader gantry to indicate when a toll transponder passes under the reader. Under this approach, enforcement personnel must be within the line of sight of the tolling zone in order to see both the overhead beacon and the triggering vehicle. Also, many electronic toll collection systems do not process billing transactions in real time, so this approach cannot determine if a transponder is linked to a valid toll account; it merely indicates that a readable transponder is present in the vehicle. Compact and portable transponder verification systems are available in hand-held configurations, which are suitable in situations where a suspected violator has been pulled over by an enforcement officer. In-vehicle transponder verification systems enable enforcement officers to remotely verify transponders while driving alongside or behind vehicles in the HOT lanes.



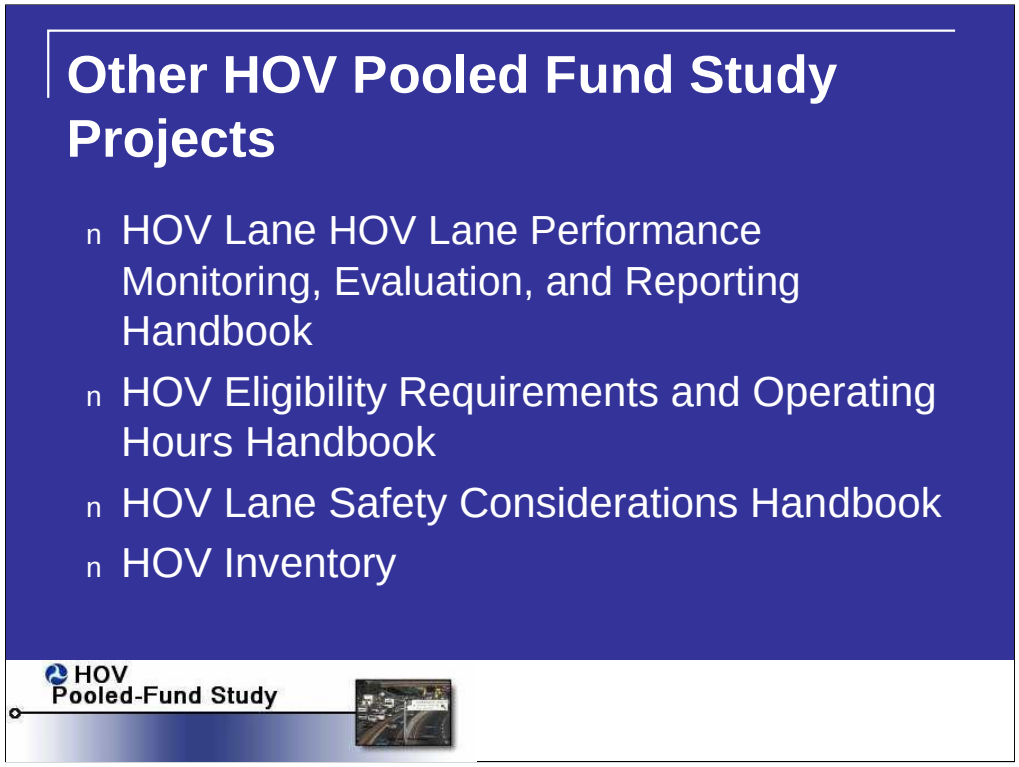
The appendices contain a glossary of terms and the references used in the handbook along with additional resources.

- Appendix A – Glossary of Terms

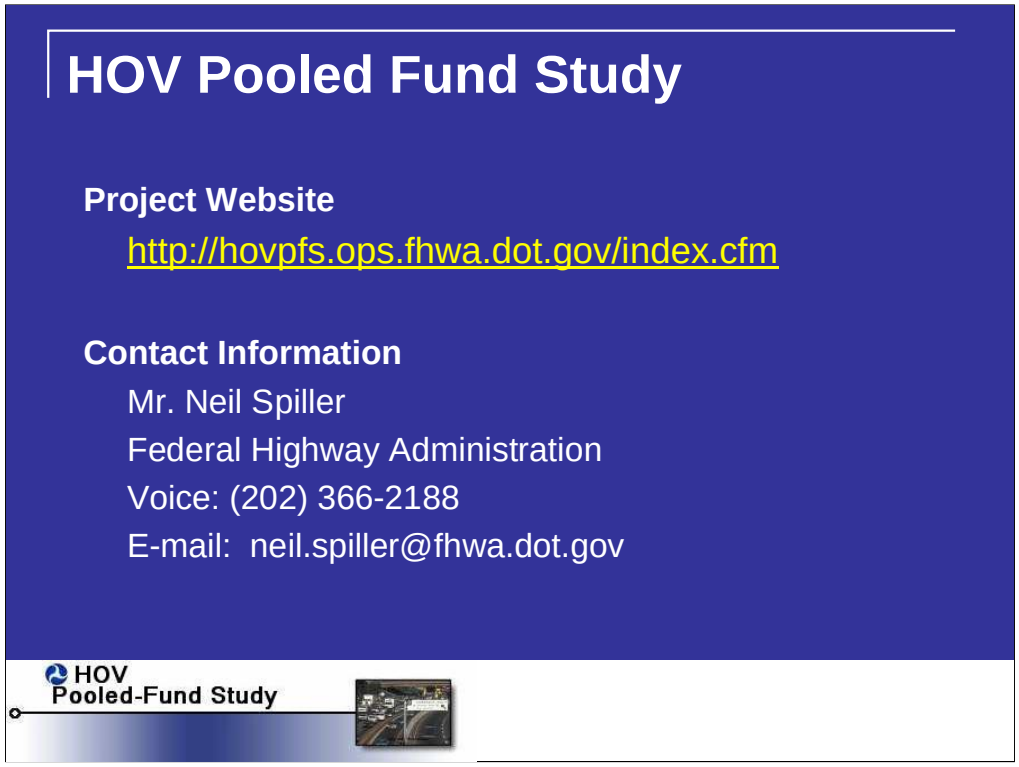
  Provides a glossary of commonly used terms associated with HOV-Lane Safety.

- Appendix B - References

  Provides the references used in the handbook and additional resources.



Other HOV pooled fund study projects are highlighted on this slide.



More information on HOV Pooled Fund Study projects, including the HOV Safety Considerations Handbook, can be obtained from the website shown on the slide or by contacting Neil Spiller at FHWA.